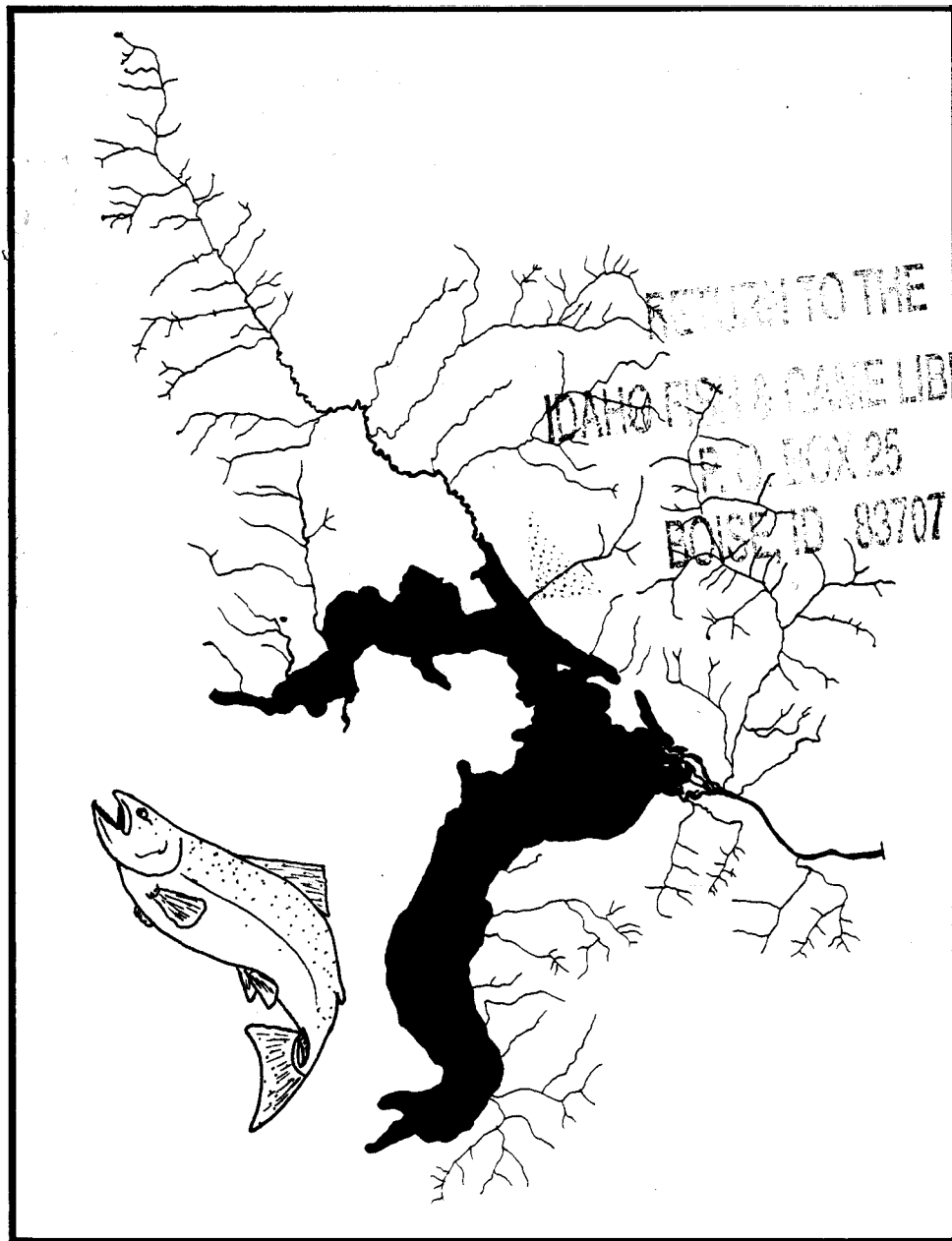


PEND OREILLE TROUT AND CHAR LIFE HISTORY STUDY

IDAHO DEPARTMENT OF FISH AND GAME
in cooperation with
LAKE PEND OREILLE IDAHO CLUB



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ABSTRACT

Adfluvial trout and char populations in the Pend Oreille drainage were assessed in 1983. The distribution and relative abundance of juvenile rainbow trout, presumably the Gerrard strain, (Salmo gairdneri), bull trout (Salvelinus confluentus), westslope cutthroat trout (Salmo clarki lewisi) brown trout (Salmo trutta) were assessed in 38 tributary streams at 52 sites. Bull trout spawning escapement was estimated to be 3,175 fish. Areas used by spawning bull trout were delineated. Likely sites for rainbow and cutthroat trout spawning were identified for further review.

The fall trout fishery was evaluated with a partial creel census and compared with data from 1975-80. The trophy rainbow harvest and angler effort had increased although catch rates for past years were similar. Rainbow trout size was assessed and compared with past years. The average length, weight and condition of trophy size rainbow trout had not changed significantly. However, both a period of highly variable fish condition from 1976-79 and a declining condition of 43-53 cm rainbow was noted.

Trout age and growth was also assessed. Rainbow trout growth rates did not seem to change between 1983 and the 1972-76 work of Anderson (1978). Most rainbow trout grew at an accelerated rate (interpreted to be their first year in the lake) as age 2 fish. Most rainbow spawned between 5 and 7 years of age. Very few repeat spawners were noted in the 1983 sample.

Rainbow trout began showing up in the trophy fishery as early as a 2- and more commonly 3-year old fish. Total annual mortality was estimated at 31% to 48%.

Age and growth determinations were also made for cutthroat and bull trout. The growth rate of both species was high in comparison with other drainages.

INTRODUCTION

Pend Oreille Lake is well known for both its salmon and trophy trout fisheries. Although kokanee (Onchynchus nerka) provide more than 90% of the catch, nearly half (46%) of the fishermen in 1980 were seeking trout (Ellis and Bowler 1981). The Gerrard strain of Kamloops rainbow trout (Salmo gairdneri) and the native bull trout (Salvelinus confluentus) attain trophy size on a diet of kokanee. The record rainbow of 37 pounds and bull trout of 32 pounds were caught in Pend Oreille Lake during the late 1940s. The largest trout caught in 1983 was a 31.5-pound (14.3 kg) rainbow trout. Other salmonid species in the fishery include westslope cutthroat trout (Salmo clarki lewisi), brown trout (Salmo trutta), lake whitefish (Coregonus clupeaformis) and lake trout (Salvelinus namaycush).

The sport fishery has been important to the residents around Pend Oreille Lake for many years. Resorts along the lake provide facilities to weigh and display trophy-size trout. Local fishermen have organized into several clubs including Lake Pend Oreille Idaho Club, Trout Unlimited, Ponderay Sportsmen and the Clark Fork Rod and Gun Club. Since 1945, an annual spring trophy fishing derby has been conducted on the lake. In 1979, a fall derby was also initiated. Over 1,800 people were registered for the spring and 672 for the fall fishing derby in 1983.

In 1982, local sportsmen expressed interest in assisting directly with management of the Pend Oreille Lake fishery. The Lake Pend Oreille Idaho Club provided funding in cooperation with the Idaho Department of Fish and Game for this evaluation of trout populations in the Pend Oreille basin.

Pend Oreille is the largest, natural lake in Idaho with surface area of 383 square km, mean depth of 164 m, and maximum depth of 351 m. The Clark Fork River is the largest tributary to the lake and drains 96% of the 59,311 square km Pend Oreille watershed (Rieman 1976).

Historically, cutthroat, bull trout and mountain whitefish were present in Pend Oreille Lake. Rainbow trout were introduced in 1942. Rainbow, cutthroat and bull trout are adfluvial in their native range. Tributaries to the lake, including the Clark Fork River, provide spawning and rearing habitat for adfluvial fishes (Fig. 1). Since the construction of Cabinet Gorge Dam in 1951, only 16 km of the Clark Fork River are available for the spawning and rearing of adfluvial fish. The remaining spawning and rearing habitat available to adfluvial trout and char consists of smaller tributaries to the lake and lower Clark Fork River (Appendix A). A total of 173 km of streams support the trout fishery in the lake today.

The number of rainbow in the catch increased steadily from 1951 to 1960 while the catch of native cutthroat and bull trout declined (Irizarry 1973). The number of cutthroat in the catch continued to decline and remains low today (Fig. 2). The bull trout catch seems to have stabilized at a low level (Fig. 3). Rainbow remain the

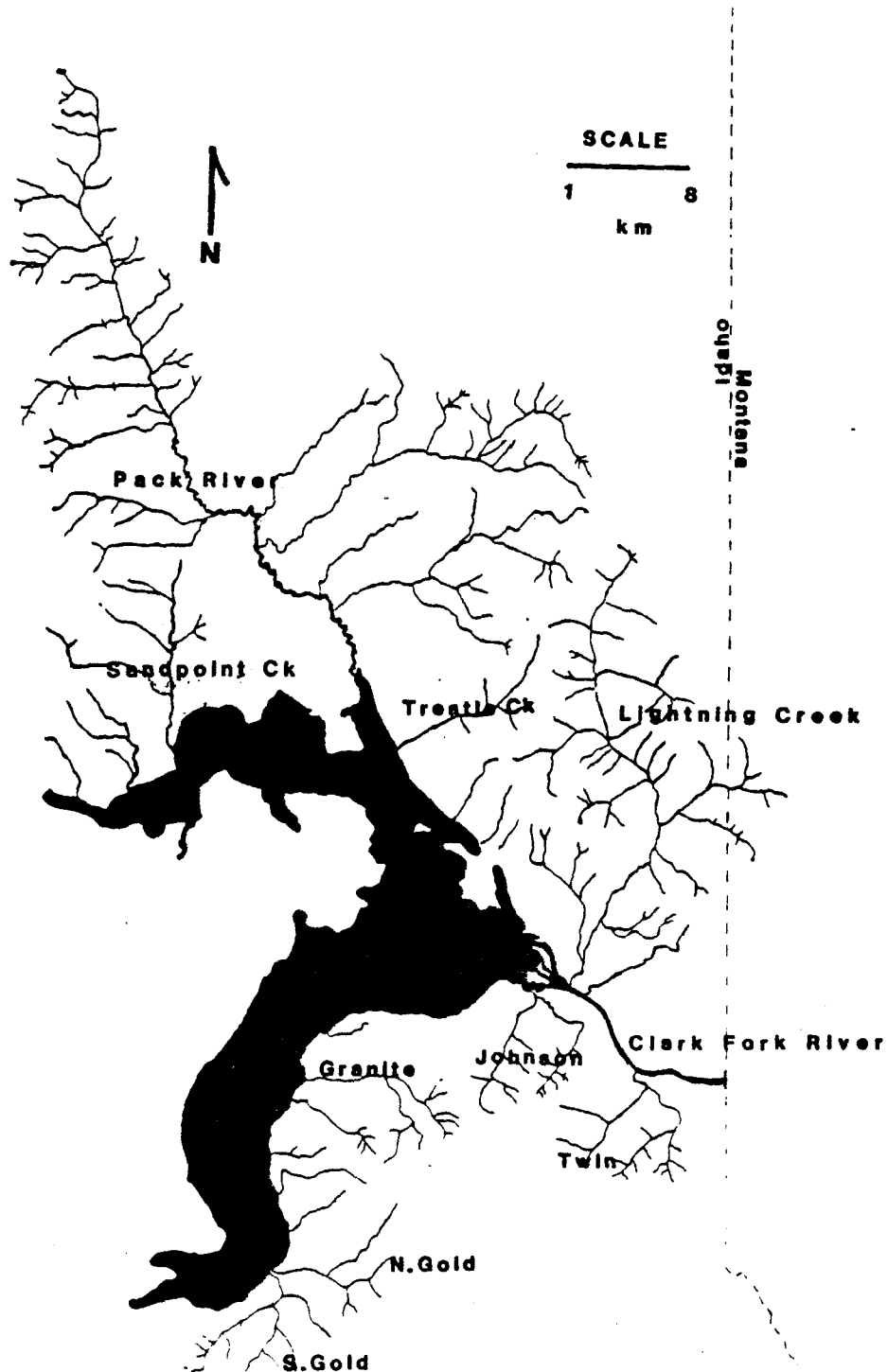


Figure 1. Tributaries available to adfluvial trout and char in the Pend Oreille Lake drainage.

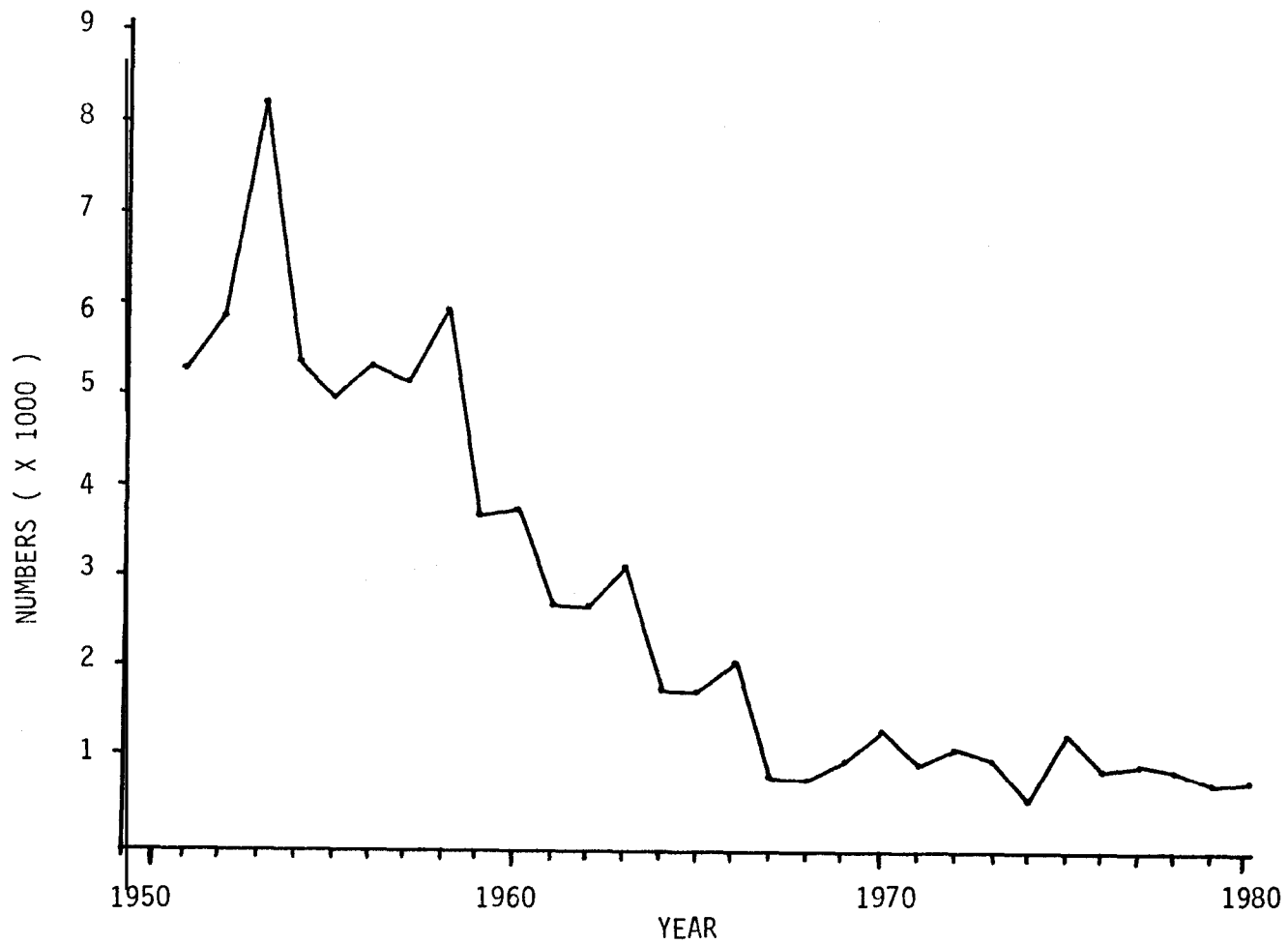


Figure 2. Estimated harvest of cutthroat trout in Lake Pend Oreille, Idaho, 1950- 1980 (from Ellis and Bowler 1981).

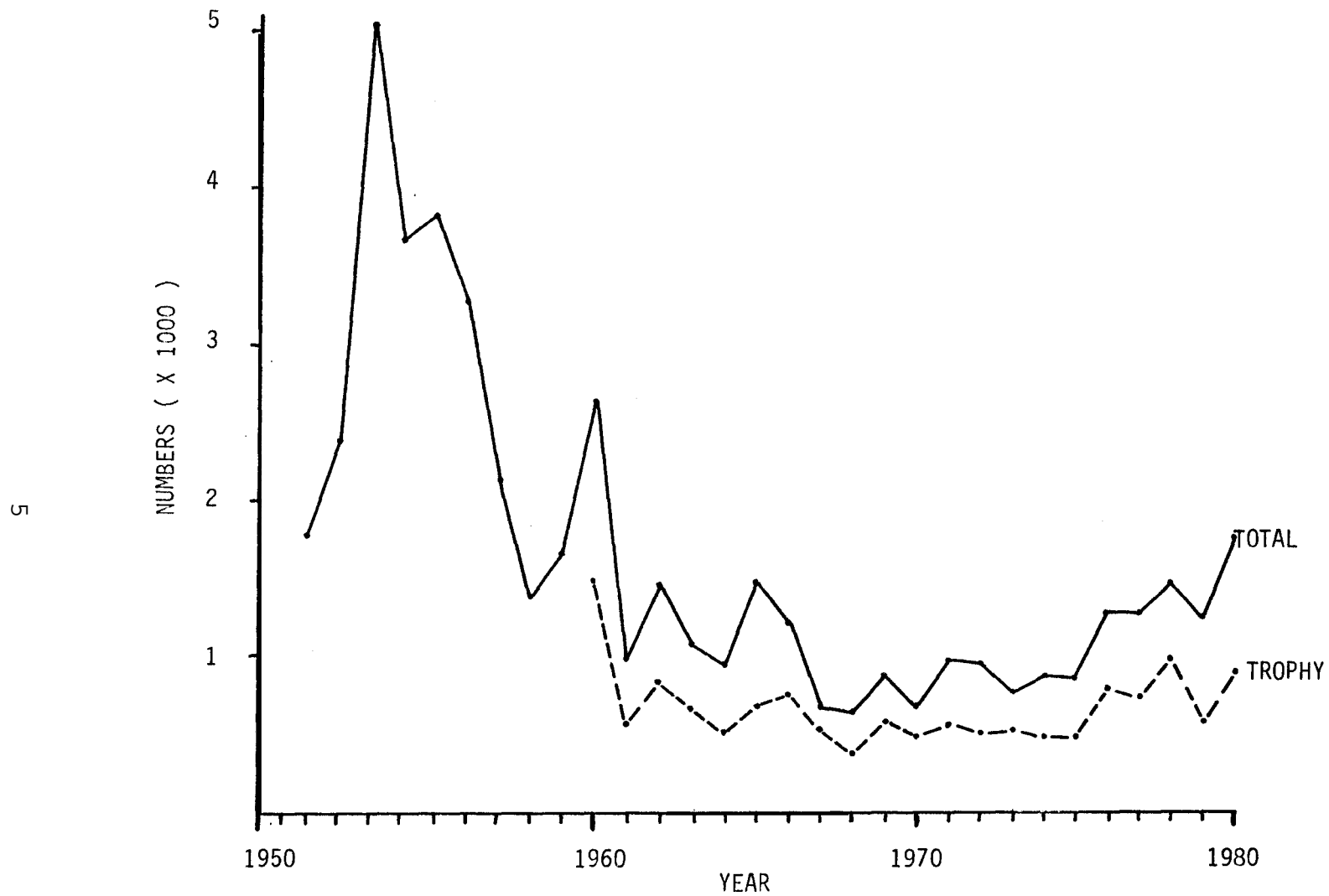


Figure 3. Estimated harvest of bull trout and trophy bull trout from Lake Pend Oreille Idaho, 1950-1980, (from Ellis and Bowler 1981).

predominant trout fishery in the lake today (Fig. 4). Although numbers declined for a period in the 1960s and early 1970s, the rainbow catch has recently increased (Ellis and Bowler 1981).

The other trout and char species in the lake have not contributed very much to the trout fishery. Brown trout and lake trout are present in the Pend Oreille Lake system. Brook trout were planted in 1914.

OBJECTIVES

1. Assess the distribution and relative abundance of juvenile trout and char in tributaries to Pend Oreille Lake.
2. Locate areas used for spawning by bull trout in tributaries to Pend Oreille Lake.
3. Identify likely spawning areas for Gerrard rainbow (Kamloops) and cutthroat trout.
4. Assess the current age structure of Lake Pend Oreille trout populations.
5. Assess the growth rates of Lake Pend Oreille trout populations.
6. Evaluate trends of angler use of trout species in Pend Oreille Lake.

RECOMMENDATIONS

1. Augment the fish distribution and abundance survey with:
 - a) additional snorkeling transects in the longer and the diverse drainages;
 - b) initial surveys of tributaries to the Pend Oreille River.
2. Repeat mortality estimates for rainbow trout and attempt to get large enough samples to estimate bull trout and cutthroat trout annual mortality.
3. Monitor fall condition of rainbow trout.
4. Monitor bull trout spawning escapement.
5. Conduct a drainage-wide stream habitat inventory using methods which could be compared to both Montana Department of Fish, Wildlife and Parks (1983) and the Idaho Panhandle National Forests habitat inventory.
6. Assess the extent of rainbow-cutthroat hybridization in the drainage and its effect on both the cutthroat and Gerrard strain rainbow trout populations.

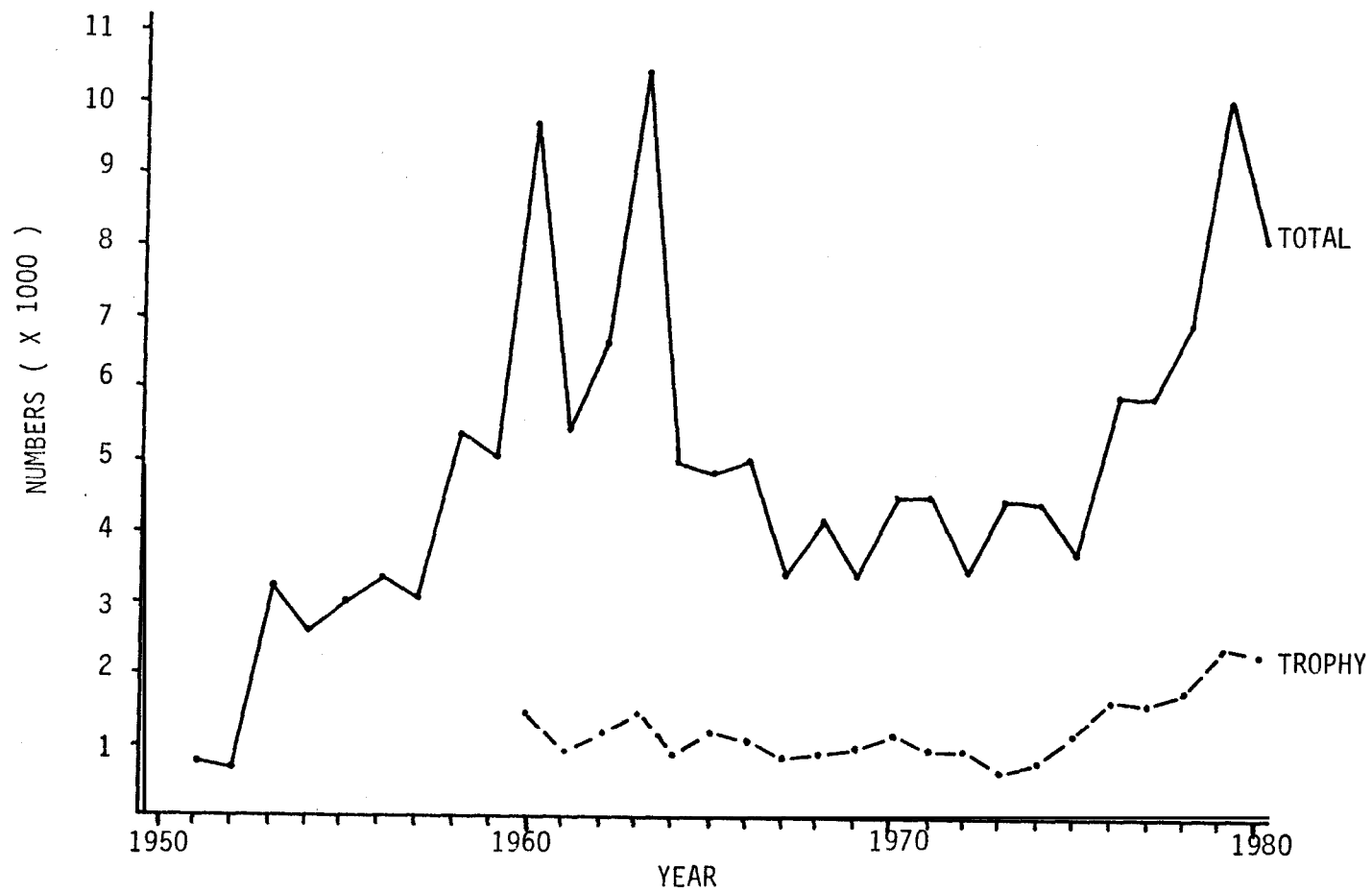


Figure 4. Estimated harvest of rainbow and trophy rainbow trout from Lake Pend Oreille Idaho, 1950-1980 (from Ellis and Bowler 1981).

7. Stream rehabilitation measures should be considered for (a) Spring Creek spawning gravels; and (b) Granite Creek through the beaver dam area between the road to Kilroy and the mouth of Sullivan Springs.
8. Assess the contribution of the Clark Fork River in terms of (a) rainbow and bull trout spawning habitat; and (b) juvenile trout and char rearing area.
9. Identify rearing areas for rainbow trout in Pend Oreille Lake.
10. Develop population statistics for the drainage and develop methods to assess rainbow trout spawning escapement.
11. Begin studying the brown trout population and conduct redd counts to estimate brown trout escapement.

METHODS

Fish Distribution

Rearing Areas

Snorkeling techniques were used to assess fish distribution and relative abundance in tributary streams to Pend Oreille Lake. These techniques included underwater observation of fish and estimation of the surface areas of observation sites. An observer dressed in a full wetsuit, snorkel and mask slowly crawled upstream counting and categorizing fish by species and life history stage. Life history stages were approximated by three size classes generalized from age growth data for cutthroat and bull trout in the Flathead River drainage (Graham et al. 1980, Fraley et al. 1981, Leathe and Graham 1982). Life history stages were: 1) fry (<80 mm), 2) juvenile (80-250 mm) adult (>250 mm). Surface area of a snorkeled site was estimated by multiplying the average of several width measurements by the length of stream snorkeled. The length of stream snorkeled varied with stream size and habitat composition. Criteria described by Montana Department of Fish, Wildlife and Parks (1983) were used to define areas as a pool, run, riffle or pocket water type of habitat unit. A pool and adjacent riffle (or run) would be snorkeled and measured. In areas where pocket water was the only type of habitat unit at least 30 meters of stream were snorkeled.

At least one snorkeling site was selected in each tributary stream. The sites were selected with three considerations: (1) representation of the stream habitat in the area, (2) easy identification and relocation of the site, and (3) accessibility. It was necessary to snorkel several sites in several streams to encompass the variation in habitat from the headwaters to the mouth of the stream.

Fish densities were calculated as a measure of relative abundance for each site snorkeled. Total fish density and densities of each trout species were calculated. All measures of density were expressed as fish per 100 square meters for ease in comparison with other areas.

Spawning Areas

Bull Trout

Redd counts were used to identify bull trout spawning areas. Bull trout redd counts have also been used as an index of abundance and estimate of spawning escapement (Graham et al. 1980, Fraley et al. 1981, Shepard et al. 1982). The effectiveness of redd counts as a basin wide indicator of bull trout distribution and abundance depends on: (1) the stream selected for survey, (2) the timing of the survey, (3) consistency of the criteria used to identify redds, and (4) method used to describe distribution of reads.

Streams were selected for spawning surveys if bull trout had been observed in the stream during the assessment of rearing areas. Most streams were surveyed from a migration barrier, such as a waterfall, to the mouth of the stream.

Redd counts were conducted in tributaries to Pend Oreille Lake between September 14 and October 6, 1983. The time period selected was similar to dates reported for bull trout spawning in the Flathead River basin of Montana (Graham et al. 1980, Fraley et al. 1981, Shepard et al. 1982).

In order to refine timing of redd counts several areas were resurveyed and observations of spawning activity as well as the number of adult bull trout were recorded during all surveys.

To be identified as a redd, the site had to be an exceptionally clean gravel area with a tail or mound of loose gravel downstream from a depression. The number of distinct depressions was used as a number of redds in areas where several redds seemed to be superimposed. If stream flow could have created the same shape and size gravel disturbance, the site was not classified as a redd. A site was not classified as a bull trout redd unless it was at least 0.3 x 0.6 meters and gravels at least 3 inches in diameter had been moved in order to avoid confusion with another fall spawning fish, the brook trout.

The distribution of spawning within a stream was recorded by counting footfalls or paces between redds and landmarks while walking along the stream. The number of paces and the map distance between landmarks were used to calculate a conversion factor of paces per kilometer for each survey. The distribution of redds within a survey section and redd densities were calculated.

Bull trout spawning escapement was estimated by multiplying the number of redds observed by 3.9 fish per redd (Fraley et al. 1981).

The estimated 3.9 fish per redd was calculated from trapping and redd count data for streams in the Flathead River basin and is the only data of that type found in the literature for bull trout.

Rainbow and Cutthroat Trout

Sections of stream were identified as possible spawning areas for cutthroat and rainbow trout where fry and appropriate substrate were observed. Past records of spring spawning were also reviewed.

Creel Census

Angler pressure effort and harvest of trophy rainbow was assessed from October 15 to November 30 at Garfield and Ellisport bays. The time period and locations were selected because trout have dominated the fishery and comparable data were available (Ellis and Bowler 1980). The six-week period was stratified into three 2-week periods. The week was divided into three "day-types," Saturdays, Sundays and weekdays. One of each day-type was randomly selected during each two-week period for each census site.

Anglers were interviewed at the census site. Number of anglers, hours fished, species sought and the catch were recorded. Estimates of pressure, effort and harvest were made by expanding the data by day-type. The 1983 estimates were compared to estimates made with the same methods from 1971-80.

Fish Population Structure

Age and Growth

Length, weight and scales were collected from rainbow, cutthroat, bull trout and a few brown trout by cooperative sportsmen and resort personnel around Pend Oreille Lake from mid-July to the end of November. Fish were measured to the nearest 1/4 inch. Weights were measured to the nearest 1/8 pound, usually at resort locations. Fish scales were collected from the caudal peduncle region where they first form below the adipose fin and above the lateral line (Brown and Bailey 1952).

Impressions of trout scales were made with one of two methods. Rainbow trout scales were placed on cellulose acetate sheets and pressed at 30 seconds at 210 F and 20,000 lbs pressure (Leathe and Graham 1981). Bull trout, cutthroat and brown trout scales were placed on plastic laminates and pressed under 20,000 lbs pressure without heat similar to methods described by Dery (1983). Scale impressions on plastic laminate produced a more easily read impression for the finely sculptured scales than the acetate and heat method.

Fish scale impressions were read at 41 x magnification using an Eberback scale reader. The distance from the focus to each annulus (or year mark) and the edge of the scale were measured at a 30° angle from the longest axis of the scale. Regenerate or eroded scales were not used for the growth analysis.

Annuli were determined by the observation of incomplete circuli and compaction (narrow spacing between circuli) followed by widely spaced circuli (Ricker 1968). Summer checks, or a false year marks formed in August have been reported for rainbow in Pend Oreille Lake (Anderson 1978). All criteria were met before an annulus was identified to prevent over-estimation of trout ages.

Development of accurate body-scale relationships was difficult due to the lack of small fish in the samples. Therefore, the length of each species at scale formation was determined from the literature for rainbow and cutthroat trout. Rainbow trout form scales at approximately 34.4 mm (Anderson 1978, Smith 1955). The smallest westslope cutthroat trout observed with scales in the Flathead River basin was 38 mm (Graham et al. 1980). No empirical data was available for the length of bull trout at scale formation. A body scale relationship was developed for bull trout, realizing the correction factor C would be an over-estimate of length-at-scale formation.

Fish length at each annulus was calculated using the formulae:

$$L^1 = C + (S^1) (L-C) \text{ where}$$

L = length of fish at capture

L^1 = length of fish at annulus formation

C = constant (correction factor for length of fish at scale formation)

S = total scale radius

S^1 = scale radius to annulus

All calculations were done with a Hewlett-Packard (33 E) calculator.

A sample of 60 rainbow trout scales were selected at random from the samples collected between 1972 and 1976 and analyzed by Anderson (1978). Average back-calculated lengths derived from the 60 scales were compared to the results of Anderson (1978) and the results of this study.

Age Composition

Representative length data were collected by cooperative fishermen who recorded the length of each fish caught, whether or not the fish was kept. Length frequencies derived from this data were used to delineate age structure of the population. Survivorship curves were constructed from length frequency and age data to estimate mortality.

RESULTS

Fish Distribution

Maps of tributaries including the location of snorkeling and redd surveys are found in Appendix B.

Rearing Areas

Rainbow and cutthroat trout were the most widely distributed species (Table 1). Cutthroat trout were observed in thirty-two (84%) of the thirty-eight streams under consideration. Rainbow trout were observed in twenty-seven (71%) streams. Streams with cutthroat but not rainbow trout were characteristically headwater areas. Streams with rainbow but no cutthroat were characteristically the lower stream reaches. The *densities* of each trout species observed at 52 sites within 34 tributary streams also demonstrated the trend of cutthroat trout predominating the upper reaches and rainbow trout the lower or downstream reaches of streams with suitable rearing habitat (Tables 2, 3, 4).

Brown trout were rarely observed in tributaries to Pend Oreille Lake. Juvenile brown trout were observed in only two (5%) tributaries (Table 3). Johnson and in creeks were small tributaries to the Clark Fork River. Other trout and char species were also observed in both streams (Table 3).

Bull trout were observed in less than half (42%) of the streams (Tables 2, 3, 4). Portions of Twin, Johnson, Lightning, Granite, West Gold and South Gold creeks were used by bull trout (Tables 3, 4). Bull trout use of the Pack River was limited. Juvenile bull trout were observed from Martin Creek upstream to the second set of steep cascades. Bull trout were observed in portions of three Pack River tributaries: lower Hellroaring Creek, upper Grouse Creek and Rapid Lightning Creek. Regions not used by bull trout were the Sandpoint Creek drainage, Falls Creek and Cedar Creek.

Brook trout were observed in less than half (47%) of the tributary streams (Table 1). Brook trout were the most abundant species in Sandpoint, Falls, Cedar, Twin and the upper reaches of Sand creeks (Table 4).

The distribution pattern of juvenile trout and char was similar in the Pack River and Lightning Creek drainages (Tables 2, 3). Rainbow and brook trout were more frequently encountered and were present in higher densities in the lower stream reaches. Cutthroat and bull trout predominated the upper stream reaches. Cutthroat were the only species present in areas above waterfall barriers. Rainbow, cutthroat, bull trout and brook trout were not observed together at any survey site in the Pack River drainage, and were observed together in only four of the Lightning Creek drainage surveys.

Table 1. Fish species observed (+) in tributaries to Pend Oreille Lake, 1983.

Stream	Methods of observation		Species observed							
			Trout			Char		Other		
	Snorkeling	Other'	Rain-bow	Cut-throat	Brown trout	Bull trout	Brook trout	kokanee	white-fish	Rough fish
<u>Clark Fork River</u>										
Johnson	+	+	+	+	+	+			+	
Lightning Spring	+		+	+		+	+	+		
Cascade		+		+						
Morris	+		+	+						
East Fork	+		+	+		+	+			+
Savage	+		+	+		+				
Char		+	+			+				
Porcupine	+		+	+		+	+			+
Wellington	+		+	+		+	+			
Rattle	+		+	+		+				
Mosquito		+	+	+			+			
Twin	+		+	+	+	+	+			
<u>Eastern Shore</u>										
Granite	+		+	+		+				
Falls	+						+			
Cedar	+						+			
North Gold	+	+	?	+		+		+		
Gold (South)	+	+	+	+		+		+		
West Gold	+			+						
<u>Northern Shore</u>										
Trestle	+	+		+		+		+		
Pack River	+		+	+		+	+		+	+
Trout	+		+	+						
Rapid Lightning	+	+	+	+		+	+			+
Gold	+		+							
Grouse	+		+			+	+			+
NF Grouse	+		+	+			+			
Sand	+		+	+			+			+
Berry	+		+	+			+		+	
Colburn	+		+	+			+			
Caribou	+		+	+						
Hellroaring?	+		+	+		+	+			
Jeru	+			+						
Youngs	+			+						
McCormick	+			+						
Sand [Sandpoint]	+		+	+			+		+	+
Spring Jack	+				-none seen-			83 planted		
Schweitzer	+			+			+			
Little Sand	+		+	+						
Percentage of streams species -was observed			68	82	5	45	47			

1. Included visual observations and electrofishing.
2. Only rainbow trout were found above the Pack River road.

Table 2. Summary of fish distribution and relative abundance (density-fish/100 m²) data collected during the 1983 field season in the Pack River and its tributaries, Pend Oreille drainage, Idaho.

Stream	Date	water tem C	Density-fish/100 m ²						Total
			Rain- bow	Cut- throa	Unidentified Salmo	Bull trout	Brook trout	Other fish	
Pack River									
site 1	8-17-83	11.0	0.3	6.7	0.3	--	--	--	7.4
site 2	8-19-83	16.0	--	11.6	--	2.4	--	--	14.0
site 3	8-19-83	16.0	--	14.8	--	2.2	--	--	17.1
site 4	8-17-83	17.0	12.8	0.4	--	0.4	--	-- ₁	13.6
site 5	8-23-83	15.0	19.2	0.2	--	--	0.2	1.0 ₂	20.6
site 6	8-23-83	15.5	55.3	0.4	--	--	0.7	9.3	65.7
Trout	8-16-83	14.0	--	2.3	41.9	--	--	--	44.2
Rapid Lightning	8-25-83	15.0	0.4	7.3	--	--	0.7	1.1 ²	9.4
Gold	9-8-83	15.0	1.1	--	--	--	--	13.9 ⁴	15.0
Grouse									
site 1	8-15-83	10.0	63.4	--	--	0.8	--	--	64.1
site 2	8-15-83	22.0	38.4	0.2	--	--	--	1.6 ^{1, 2, 3}	40.1
North Fork Grouse		15.0	53.2	0.6	--	--	0.4	1.1 ¹	55.3
Sand									
site 1	8-25-83	12.5	5.4	8.6	-	-	42.9	-- _{1~4}	57.0
site 2	8-25-83	15.0					--	32.0	32.0
Berry	8-30-83	15.0	12.5	4.0	1.7	--	1.1	--	19.3
Colburn	8-24-83	12.5	5.1	0.8	--	--	0.3	--	6.1
Caribou									
site 1	8-30-83	13.0	4.4	12.7	--	--	--	--	13.1
site 2	8-30-83	14.0	20.9	1.3	4.4	--	--	--	26.6

Table 2. Continued.

Stream	Date	Water temp C	Density (fish/110 m ²)						Total
			Rain- bow	Cut- throat	Unidentified Salmo	Bull trout	Brook trout	Other fish	
Hellroaring	8-30-83	14.0	9.8						9.8
Jeru	8-17-83	14.0		38.0			0.9		38.9
Youngs (Homestead)	8-17-83	18.0		32.2					32.2
McCormick	8-17-83	17.5		0.9					0.9

1. Mountain whitefish.
2. Sculpins.
3. Suckers or squawfish.
4. Shiners.

Table 3. Summary of fish distribution and relative abundance (density-fish/100 m²) data collected during the 1983 field season in tributaries to the Clark Fork River including Lightning Creek and its tributaries, Pend Oreille drainage, Idaho.

Stream	Date	Water temp C	Density fish/100 m ²)						Total
			Rain- bow	Cut- throat	Unidentified Salmo	Bull trout	Brook trout	Other fish	
Twin Creek									
Site 1	9-8-83	11.0	92.6	1.5		4.6	238.5	47.8 ^{1,2}	321.3
Site 2	9-8-83	10.0	56.0	9.7		17.0	204.4	34.1 ²	274.7
Johnson Creek	8-31-83	10.0	2.6	0.6		4.5			7.7
Lightning Creek									
Site 1	8-18-83	10.0	--	2.2	--	--	--		2.2
Site 2	8-18-83	12.5	4.0	5.0	0.2	0.2	0.2		9.6
Site 3	8-9-83	15.0	2.6	--	--	0.2	0.1		2.9
Site 4	8-22-83	15.0	8.9			--	0.4	0.5 ¹	9.9
Morris	8-31-83		14.1	6.2	1.8				21.9
East Fork	8-9-83		4.4	1.2	1.2	4.8	0.6	0.6 ³	12.2
Savage	8-31-83		3.3	4.6	1.2	0.4			9.6
Porcupine	8-10-83	14.0	2.5	1.4	1.1	1.4	0.4	0.3 ³	7.1
Wellington	8-18-83	12.0	2.1	2.4		2.1	2.1		8.6
Rattle									
Site 1	8-5-83	--		3.1					3.1
Site 2	8-16-83	10.0		51.8					51.8
Site 3	8-16-83	11.0		8.4		3.0			11.3
Site 4	8-9-83	--	2.8		0.8				3.6

1. Mountain whitefish.
2. Brown trout.
3. Sculpins.

Table 4. Summary of fish distribution and relative abundance (density-fish/100 m²) data collected during the 1983 field season in small tributaries along the east and north shores of Pend Oreille Lake, Idaho

Stream	Date	water temp C	Density (fish/100 m ²)						Total
			Rain- bow	Cut- throat	Unidentified Salmo	Bull trout	Brook trout	Other fish	
East Side Tributaries									
Falls	9-7-83	9.5					2.3		2.3
Cedar	9-7-83	12.0					5.8	--	5.8
Granite									
site 1	8-27-83	12.0	14.4	2.0		7.6			24.0
site 2	9-7-83	8.5	0.5	1.6	--	1.6			3.7
North Gold	8-12-83	9.0		55.6					55.6
South Gold	8-12-83	11.0			2.1	2.8			5.0
West Gold	8-12-83	8.0		43.1					43.1
North Side Tributaries									
Trestle Creek									
site 1	8-11-83	11.0	--	--					
site 2	8-16-83	12.0		1.5		1.5			3.0
Sandpoint Creek	9-6-83	15.0	4.4	2.9	4.4		23.3	19.0 ^{1,3}	53.9
Spring Jack	8-24-83	15.0	--						
Schweitzer	9-6-83	10.0	15.4	3.8	1.3		5.1		25.6
Little Sand									
site 1	9-6-83	11.0	10.1	1.0	1.0		--		12.1
site 2	9-6-83	11.0	15.7	17.9	6.7			--	40.3

1. Mountain whitefish.
2. Brown trout.
3. Suckers and squawfish.

Spawning Areas

Bull trout

Bull trout redds were identified in approximately 40 km of the 103 km (64.4 miles) selected for inventory (Tables 5, 6, 7). Redds were often located in the upper reaches of accessible stream areas (Figs. 5-10).

Stream accessibility was delineated by waterfalls. The four dry stream beds noted in the Lightning Creek drainage did not confine adfluvial bull trout spawning activity, as might be expected. Many redds and bull trout (considered adfluvial because of their size) were observed above seasonally dry sections in Rattle, East Fork Lightning, Savage and Lightning creeks (Figs. 5-7).

The bull trout spawning season extended from mid-August to mid-October in the Pend Oreille drainage. Redds were observed as early as August 11, 1983 in Trestle Creek. Bull trout spawning began in Sullivan Springs between August 27 and August 31, 1983. Spawning activity and completed redds were readily observed throughout the drainage by mid-September. Spawning pairs were observed in South Gold on October 6, 1983. In contrast, spawning activity may have been completed in Trestle Creek by the first week of October. Many redds were observed but no adult bull trout spawning activity was noted October 3, 1983.

Redds observed in Granite Creek on October 26 were somewhat obscured by algae, indicating spawning had occurred at an earlier date. Sullivan Springs was examined on August 27, August 31, September 15 and October 26 for bull trout redds. No fish or redds were seen on August 27. On August 31, one pair of bull trout and one redd were observed. Nine redds were observed September 15 and only eight were visible October 26.

Ninety percent of the redds observed in the Pend Oreille drainage were in Trestle, South Gold and Lightning creek drainages. The highest densities of bull trout redds were also located in South Gold, Trestle and several Lightning Creek tributaries (Table 6).

Bull trout spawning escapement for the Pend Oreille drainage, excluding the Clark Fork River, was estimated to be 3,175 in 1983.

Rainbow and Cutthroat Trout

Spawning rainbow trout probably use the following areas of the Pend Oreille drainage based on the observation of fry and suitable spawning substrate:

1. Lightning Creek near the crossing of road 632.
2. Lightning Creek between the mouth of Cascade and Spring creeks.

Table 5. Length of stream present, available, surveyed and used by bull trout in the Pend Oreille drainage (below Cabinet Gorge dam).

Stream distance	Miles	Km	% drainage	% of area available
Present in the drainage	158.8 ¹	254	100	
Available to migrating fish	108.1 ¹	173	68	100
Surveyed for bull trout redds	64.4	103	40	23
Used by bull trout (to nearest 0.5 km)	25.0	40	16	39

1. Data from USFS, Sandpoint Ranger District.

Table 6. Bull trout redd densities calculated for regions with redds (to the nearest 0.5 km) for each tributary to Pend Oreille Lake surveyed during the 1983 field season.

Stream	Redds counted	km walked	km with redds	Redds/km
CLARK FORK RIVER				
<u>Lightning</u>	28	27.0	5.5	4.9
Rattle	51	5.7	3.5	14.6
Wellington	21	0.5	0.5	42.0
East Fork	110	6.8	5.5	20.0
Savage	36	2.1	2.5	14.4
Charr	18	1.2	0.5	36.0
Porcupine	37	3.0	2.5	14.8
Spring	0	2.0	0	0
<u>Twin</u>	7	3.2	1.0	7.0
<u>Johnson</u>	13	1.3	1.5	8.7
NORTHERN SHORE				
<u>Trestle</u>	298	8.5	8.5	35.1
<u>Pack River</u>	34	16.0	3.0	11.3
Jeru	0	0	0	0
Heliroaring	0	0	0	0
Grouse	2	2.6	1.0	2.0
Rapid Lightning	0	4.8	0	0
EASTERN SHORE				
<u>Granite</u>	3	5.8	1.0	3.0
Sullivan Springs	9	0.5	0.5	18.0
<u>North Gold</u>	16	1.2	1.0	16.0
<u>South Gold</u>	131	2.3	2.5	52.4
TOTAL	814	102.8	40.5	20.8

1. To the nearest 0.5 km. 2. where redds were present.

Table 7. Description of bull trout redd surveys conducted in the Pend Oreille drainage in 1983 including distance surveyed, number of definite redds, number of "possible" redds, and number of adult bull trout seen on the survey date.

Stream	Survey		Observations			
	Section description	Distance (km)	Date	Redds	Possible redds	Adult bull trout
CLARK FORK RIVER						
Lightning	a) Quartz Creek - Rattle Creek	2.7	9-23-83	13	3	
	b) Rattle Creek - Bridge above Wellington Creek	2.4	9-28-83	4	0	1
	c) Bridge above Wellington Creek - Highway 200	21.9	9-24-83	11 z?	5	
Rattle	Falls by upper bridge - mouth	5.7	9-29-83	51	12	8
Wellington	Falls - mouth	0.5	9-23-83	21	2	3
East Fork	a) Confluence Thunder Creek - Old road crossing	1.8	10-6-83	67	8	6
	b) Old road crossing - mouth	5.0	9-22-83	43	10	6
Savage	Old road crossing - mouth	2.1	9-29-83	36	5	4
Charr	1.2 km upstream from mouth	1.2	9-29-83	18	4	2
Porcupine	Approx 3.0 km up from mouth	3.0	9-27-83	37	11	4
Spring	Approx 2.0 km up from mouth	2.0	9-24-83	0	0	0
LIGHTNING CREEK DRAINAGE TOTAL		55.1		301	60	4

Table 7. Continued.

Stream	Survey Section description	Distance (km)	Date	Observations		
				Redds	Possible redds	Adult bull trout
Twin	a) Falls - mouth	3.2	9-21-83	7 ₁	4	1
	b) 50 paces below bridge	0.1	10-30-83	10 ¹	0	0
<u>Johnson</u>	Falls - mouth	1.3	9-21-83	13	1	1
NORTHERN SHORE						
<u>Pack River</u>	a) Cascades - bridge below McCormick	3.0	9-30-83	32	11	7
	b) Bridge below McCormick - Home- stead Creek	3.1	10-1-83	2	2	6
	c) Homestead Creek - bridge by Edna and Bucks	9.9	9-30-83	0	0	0
Jeru	Mouth upstream to barrier	1.0	10-1-83	0	0	0
Hellroaring	Mouth upstream to barrier	0.7	9-30-83	0	0	0
Grouse	a) Below Flume Creek to bridge below South Fork Grouse	2.1	10-5-83	2	1	0
	b) Grouse Creek falls, and 0.5 cm below	0.5	10-5-83	0	0	2
Rapid Lightning	Second falls to mouth •	4.8	10-3-83	0	3	0
PACK RIVER DRAINAGE TOTAL		25.1		36	17	15
<div style="border: 1px solid black; padding: 2px;"><u>Trestle</u></div>	a) 1.8 km upstream from Road 1082	1.8	10-3-83	84	10	1
	b) Road 1082 - 1.5 miles up from mouth	6.7	9-14-83	214	19	52
TRESTLE CREEK DRAINAGE TOTAL		8.5		298	29	53

Table 7. Continued.

Stream	Section description	Survey	Distance (km)	Observations			
				Date	Redds	Possible redds	Adult bull trout
EASTERN SHORE							
<u>Granite</u>	a) Upper bridge - mouth		5.85 ²	10-26-83	3	20	3
	b) Head of springs to mouth		0.5	9-15-83	9	0	1
Sullivan Springs	Head of springs to mouth		0.5	10-26-83	8 ³	2	0
<u>North Gold</u>	Log barrier - mouth		1.2	9-15-83	16	2	2
<u>South Gold</u>	Bedrock barrier - mouth		2.3	10-6-83	131	15	19 ⁴
PEND OREILLE DRAINAGE GRAND TOTAL			102.8		814	.148	137

1. This increase in redd numbers could be either bull trout or brown trout, only 1 redd seen in this 50 pace area on September 21 and not included in total.
2. Only portions of this 5.85 km were surveyed
3. Recounts not included in total.
4. Five bull trout were mortalities.

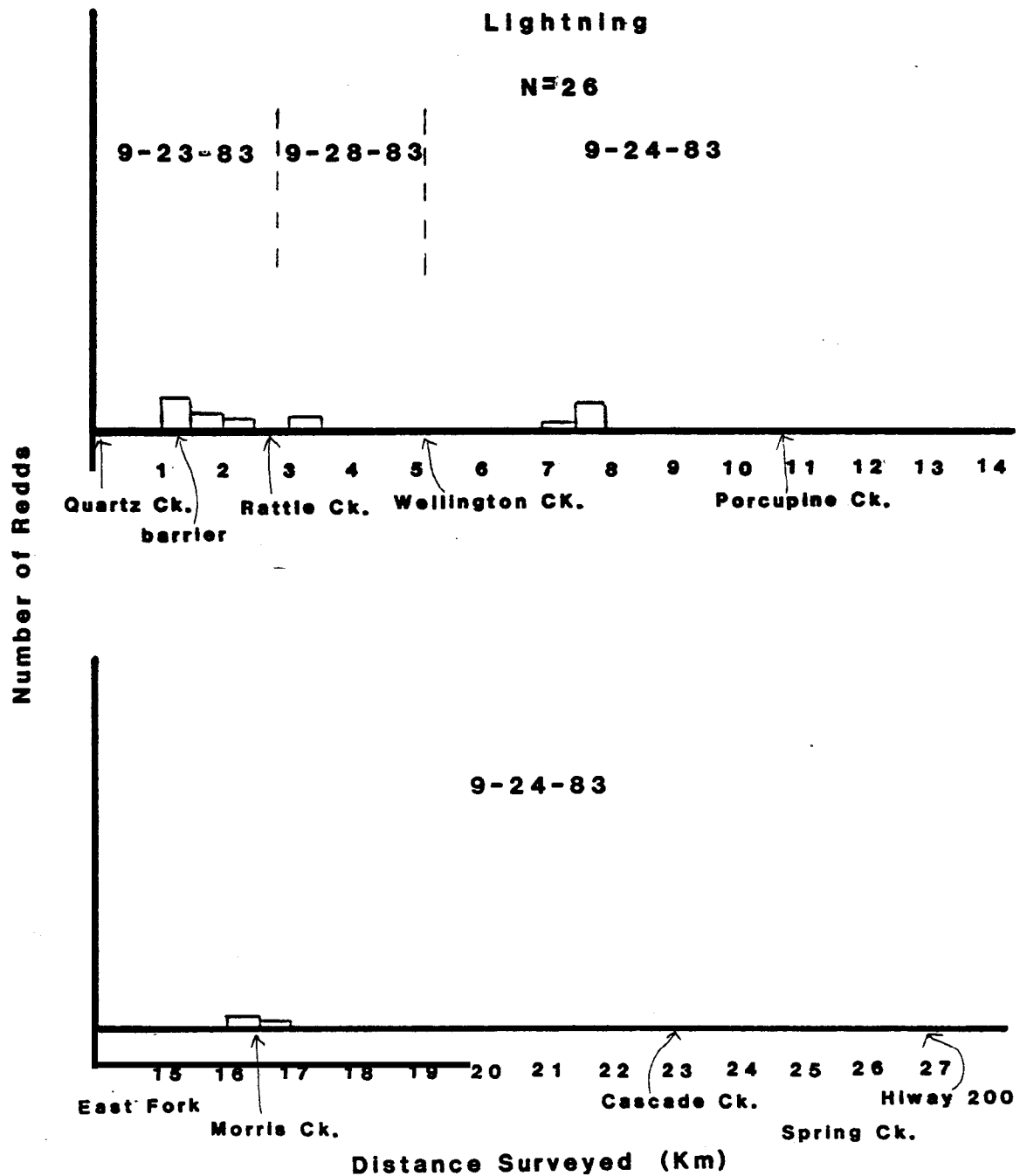


Figure 5. Distribution of bull trout redds in Lightning Creek observed on either September 23, September 28 or September 24, 1983 between the mouth of Quartz Creek and the Highway 200 bridge.

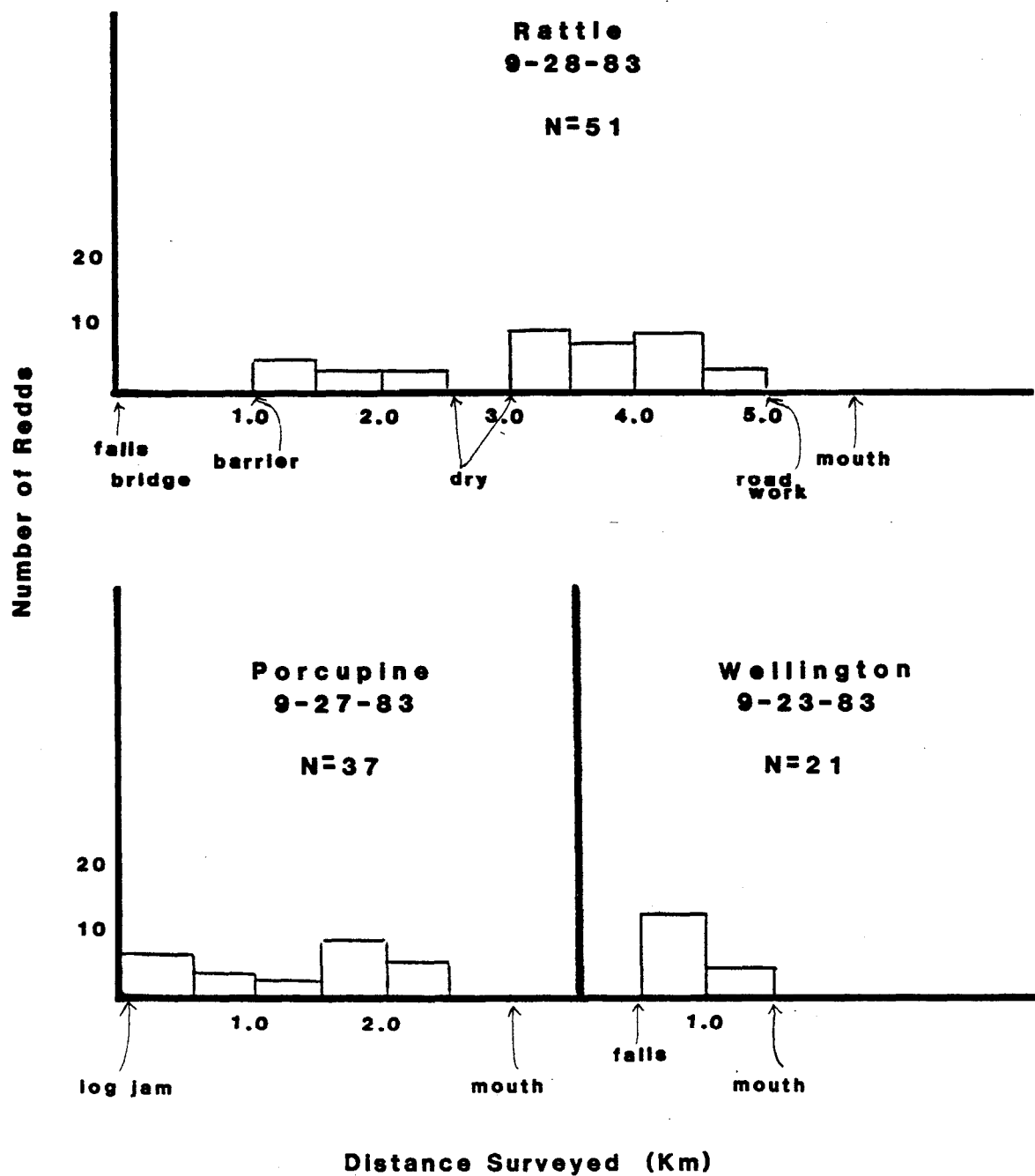


Figure 6. Distribution of bull trout redds observed in Rattle Creek on September 28, 1983, Porcupine Creek on September 27, 1983 and Wellington Creek on September 25, 1983.

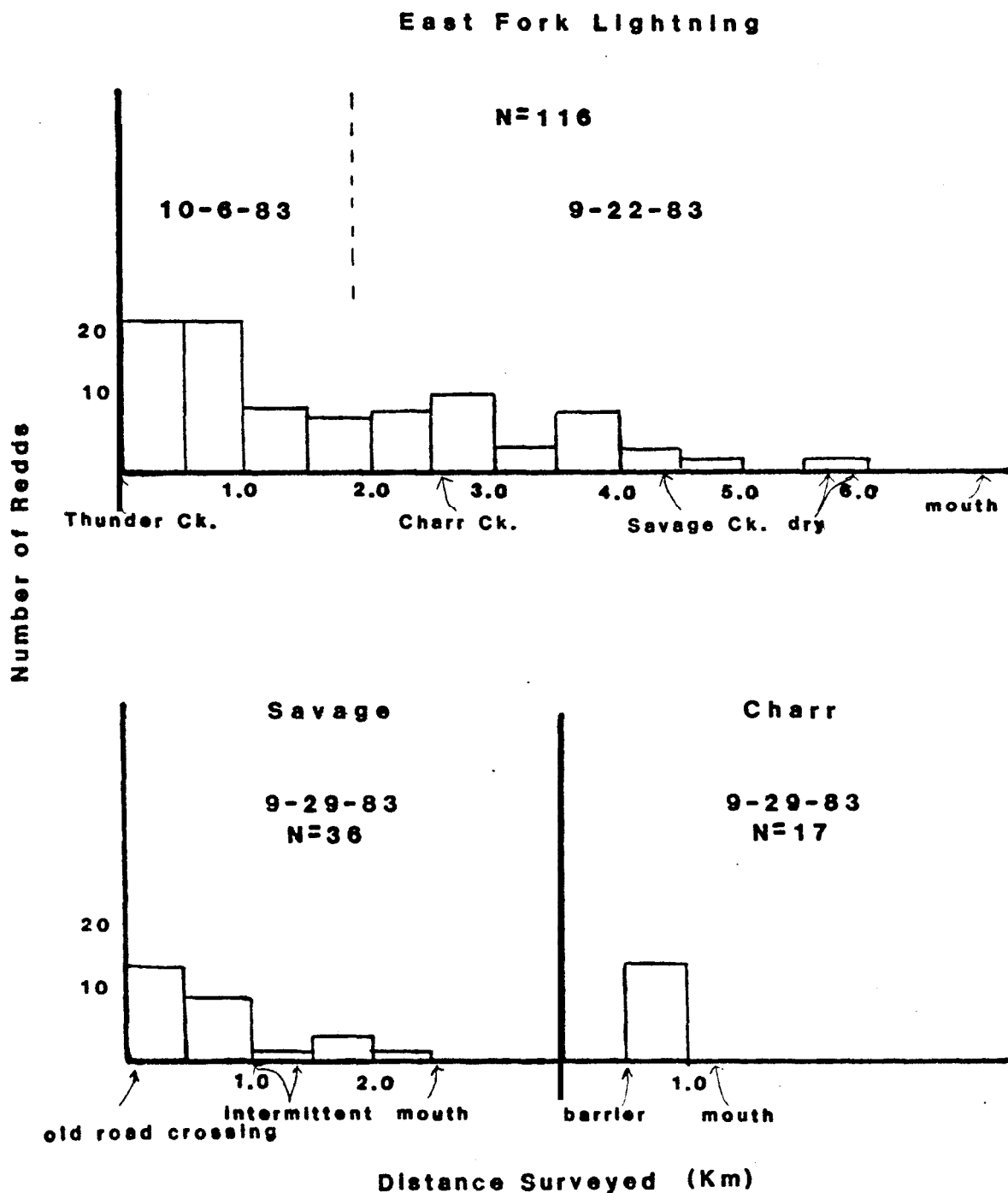


Figure 7.. Distribution of bull trout redds observed on October 6 or September 22, 1983 in East Fork Lightning Creek and on September 29, 1983 in Savage and Charr creeks, tributaries to the East Fork of Lightning Creek.

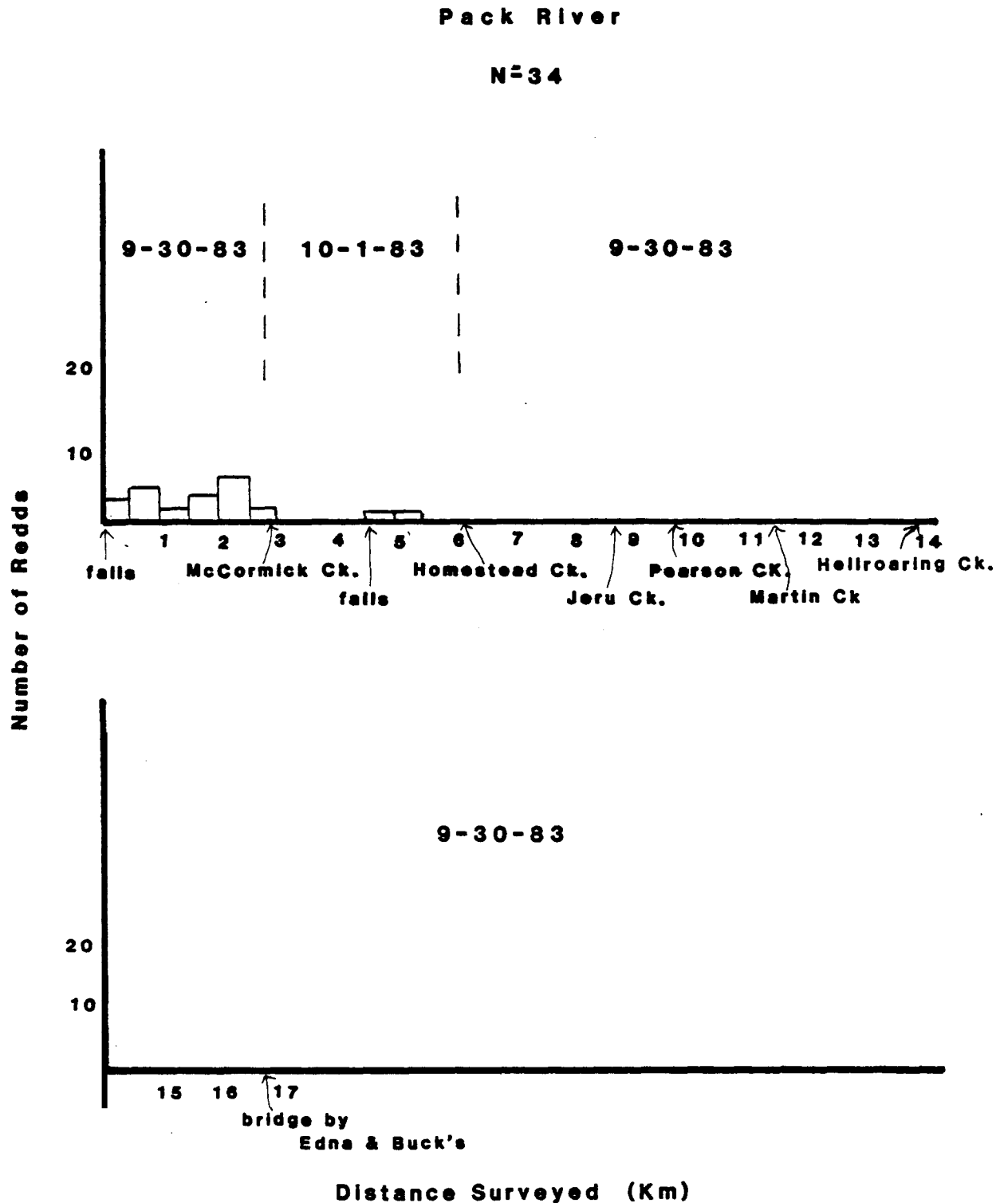


Figure 8. Distribution of bull trout redds observed on September 30 and October 1, 1983 in the Pack River from the second cascade area downstream to Pack River road bridge by Edna and Bucks Tavern.

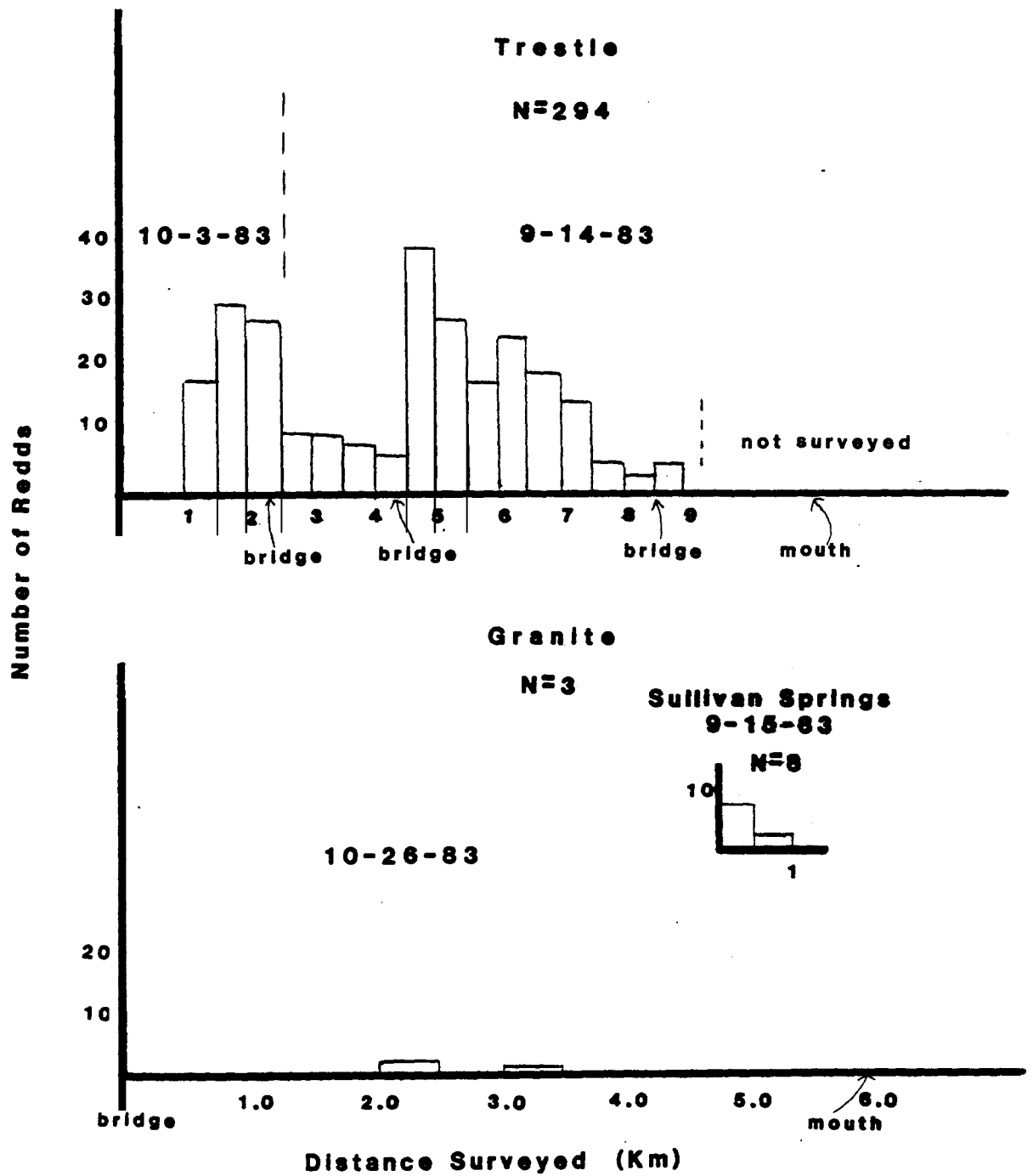


Figure 9. Distribution of bull trout redds observed on September 14 and October 3, 1983 in Trestle Creek, October 26 in Granite Creek and September 15 in Sullivan Springs (a tributary to Granite Creek).

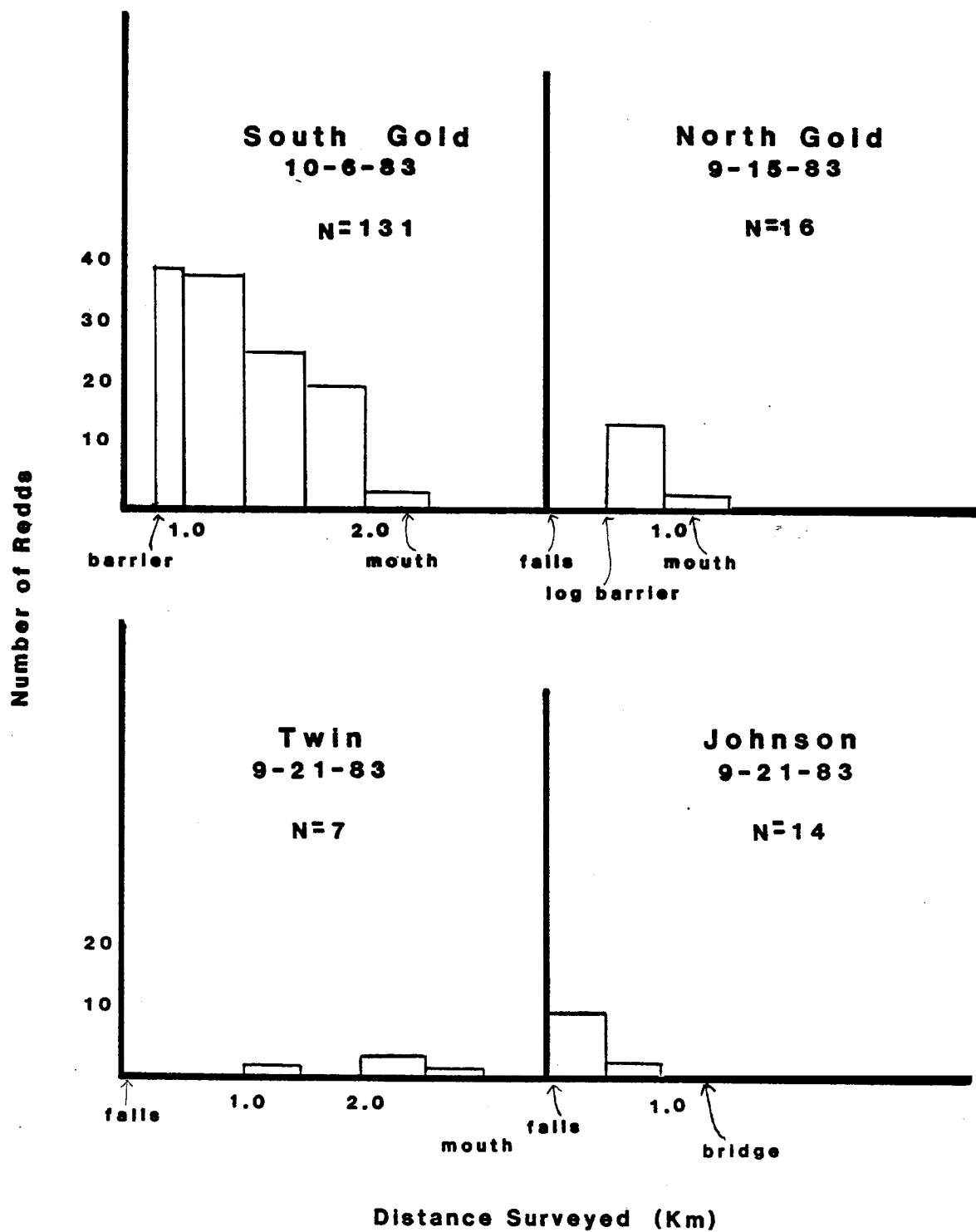


Figure 10. Distribution of bull trout redds observed on October 6 in South Gold, September 15 in North Gold, and September 21, 1983 in Twin and Johnson creeks from a barrier falls to the mouth of the creek.

3. Morris Creek.
4. Pack River near McCormick Creek.
5. Pack River between the mouth of Hellroaring and Caribou creeks.
6. Grouse Creek.
7. North Fork Grouse Creek.
8. Caribou Creek.
9. Hellroaring Creek.
10. Berry Creek.
11. Colburn Creek.
12. Twin Creek.
13. Johnson Creek.
14. Granite Creek.
15. Rattle Creek in the braided area (seasonally intermittent).
16. Savage Creek in the braided area (seasonally intermittent).

Rainbow trout spawning has also been reported in Spring Creek (Whitt 1957, Goodnight and Reiningner 1978) and Rapid Lightning Creek (Goodnight and Reiningner 1972).

Cutthroat trout probably spawn in the following areas based on the observation of fry:

1. Lightning Creek near the mouth of Quartz Creek.
2. Lightning Creek upstream from the mouth of Rattle Creek.
3. Rattle Creek.
4. Wellington Creek.
5. Morris Creek.
6. Rapid Lightning Creek.
7. Sand Creek upstream from the Elmira road crossing.
8. Berry Creek.
9. Colburn Creek.

10. Caribou Creek.
11. Jeru Creek.
12. Youngs Creek.
13. McCormick Creek.
14. North Gold Creek.
15. West Gold Creek.
16. Twin Creek.
17. Johnson Creek.
18. Granite Creek.

Other streams may also provide cutthroat and rainbow trout spawning habitat. Many small streams, the size commonly used by spawning cutthroat, were not surveyed in 1983 due to time constraints. Additional sampling may also indicate other regions within surveyed streams which could be used by spawning trout.

Cutthroat and rainbow trout have been known to exhibit resident (stream) fluvial (river to stream) and adfluvial (lake to stream) life history patterns. An adfluvial stock of rainbow trout was planted in the system; therefore, it is assumed the rainbow trout in the Pend Oreille system are adfluvial. Resident and adfluvial cutthroat trout were present in the Pend Oreille system. It was not possible to distinguish fry from resident and adfluvial stocks. It can be assumed, however, that all cutthroat trout above major waterfalls were residents (Appendix A).

Creel Census

Estimated angler effort and trophy rainbow trout harvest at Garfield and Ellisport bays from October 16 to November 30 had increased from 1975 to 1980 (Table 8). Similar trends were observed for the entire lake from 1975-80 (Table 9). Trophy rainbow trout dominated the fishery from October 16 to November 30, 1983. Very few other trout, including subtrophy rainbow, cutthroat and bull trout were harvested at Ellisport and Garfield bays between October 16 and November 30 (Table 10). Fishing effort and the harvest of trophy rainbow trout continued to increase in 1983 (Figs. 11-13). The number of hours required to catch a trophy Kamloops in 1983 was similar to the catch rates for previous years (Fig. 11).

Average length, weight and condition factors were calculated for trophy rainbow trout creeled at Garfield and Ellisport bays October 16 to November 30, from 1975 to 1983. Length weight and condition were similar among years through length and weight in 1983 were the lowest observed. Differences were not significant (Table 11).

Table 8. Estimated fishing pressure, effort and harvest of trophy Kamloops rainbow at Ellisport and Garfield Bay resorts, Pend Oreille Lake, Idaho, for the period of October 16-November 30, 1971-1983.

Year	Angler man-days	Hours	Trophy rainbow	Hours fished per trophy rainbow	Trophy rainbow per hour
1971	1,150	6,470	167	52	0.02
1972	1,197	6,179	134	46	0.02
1973	871	4,583	123	38	0.03
1974	986	4,847	59	84	0.01
1975	668	3,363	90	32	0.03
1976	1,492	7,520	170	35	0.03
1977	888	4,656	154	49	0.02
1978	1,120	5,311	133	44	0.02
1979	1,113	6,103	95	57	0.02
1980	1,893	10,206	174	61	0.02
1981	No Data	No Data	No Data	No Data	No Data
1982	No Data	No Data	No Data	No Data	No Data
1983	2,102	11,754	230	48	0.02

Table 9. Estimated minimum fishing pressure, effort and harvest for sport anglers seeking trophy Kamloops trout over 432 cm (17 in), Pend Oreille Lake, Idaho, 1975-1980.

Year	Estimated angler man-days	Estimated hours fished	Estimated trophy rainbow catch	Hours fished per trophy rainbow	Trophy rainbow per hour
1975	10,993	55,712	759	72.2	0.01
1976	15,195	79,802	1,403	64.3	0.02
1977	14,770	77,327	1,216	70.8	0.02
1978	16,897	88,969	1,334	65.6	0.02
1979	17,688	93,584	1,384	62.7	0.01
1980	20,210	108,536	1,676	61.6	0.01

Table 10. Estimated minimum harvest of cutthroat, bull trout, sub-trophy and trophy rainbow trout from Ellisport and Garfield bays October 16-November 30, 1977 to 1983, Pend Oreille Lake, Idaho.

Year	Cutthroat trout	Bull trout	Subtrophy rainbow	Trophy rainbow
1977	0	57	22	154
1978	0	62	56	133
1979	2	14	79	95
1980	4	95	128	174
1981	No Data	No Data	No Data	No Data
1982	No Data	No Data	No Data	No Data
1983	2	58	57	230

Table 11. Average length, weight and condition factor of trophy (? 432 mm) rainbow trout collected during the period October 16 to November 20 from Pend Oreille Lake, Idaho, 1976-1983.

Year	N	Length cm (in)			Weight kg (lbs)			Condition factor (x10 ⁻⁵)		
		X	SD	Range	X	SD	Range	X	SD	Range
1975	36	65.5 (25.8)	12.9	45.7-96.5	4.3 (9.5)	2.9	1.1-12.1	1.30	0.16	1.08-1.73
1976	80	64.8 (25.5)	12.0	43.2-91.4	3.9 (8.6)	2.4	0.9-10.0	1.28	0.18	0.61-1.70
1977	51	67.5 (26.6)	11.9	43.2-91.4	4.4 (9.7)	2.4	1.1-8.4	1.27	0.27	0.66-1.91
1978	46	66.5 (26.2)	12.7	43.8-88.9	4.6 (10.1)	3.1	0.9-12.2	1.34	0.35	0.79-2.08
1979	24	66.6 (26.2)	15.7	43.2-95.2	4.8 (10.6)	3.6	0.9-12.6	1.29	0.31	0.52-1.89
1980	36	66.2 (26.1)	15.9	44.4-100.3	4.0 (8.8)	3.0	0.7-10.4	1.10	0.23	0.67-1.56
1981										
1982										
1983	56	63.6 (25.0)	13.5	43.2-86.4	3.6 (7.9)	2.5	0.9-8.7	1.15	0.18	0.84-1.55
Average	329	65.6 (25.8)			4.2 (9.2)			1.25		

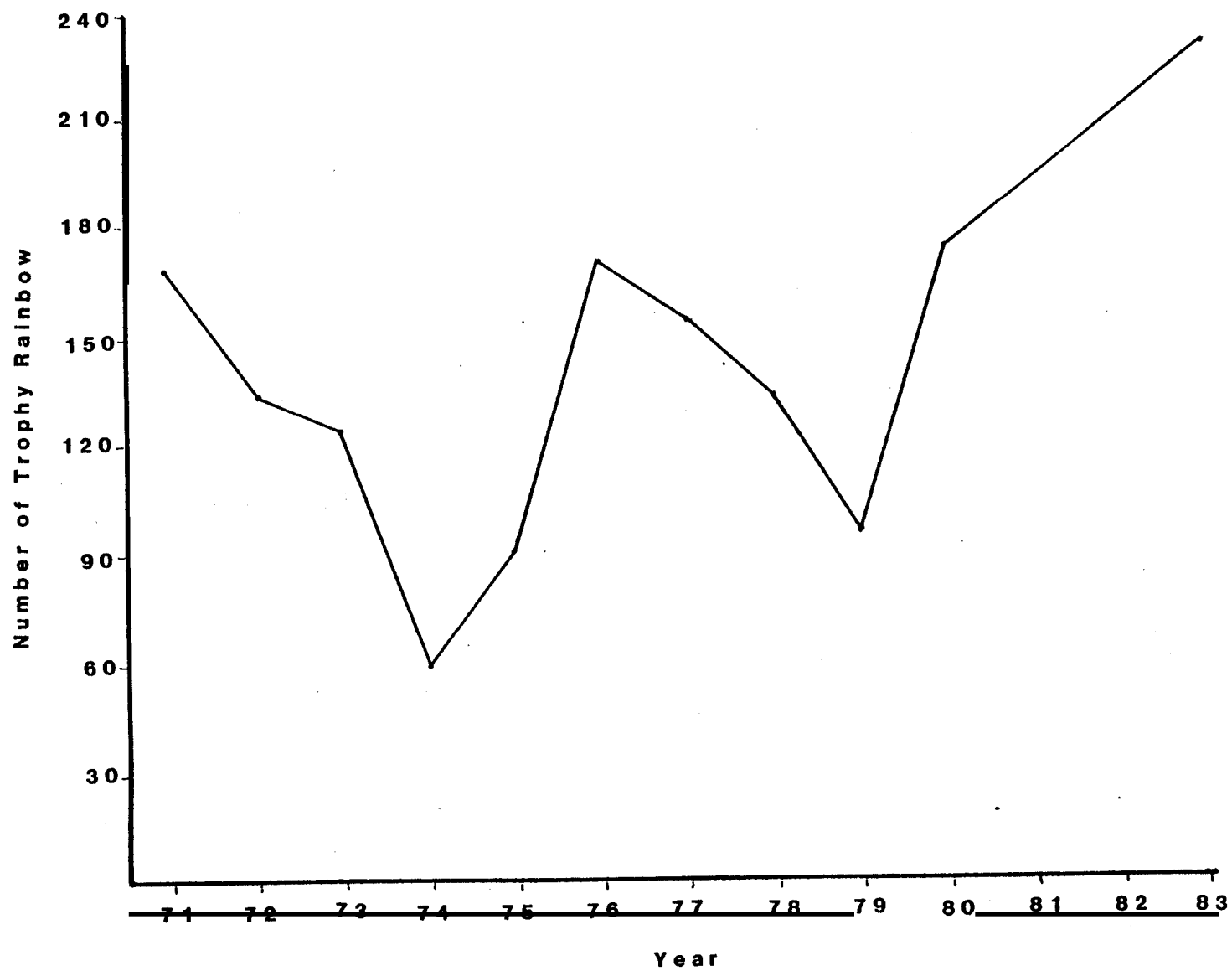


Figure 11. Estimated harvest of trophy rainbow trout October 16-November 30, 1975-1983 at Garfield and Ellisport bays, Pend Oreille Lake, Idaho.

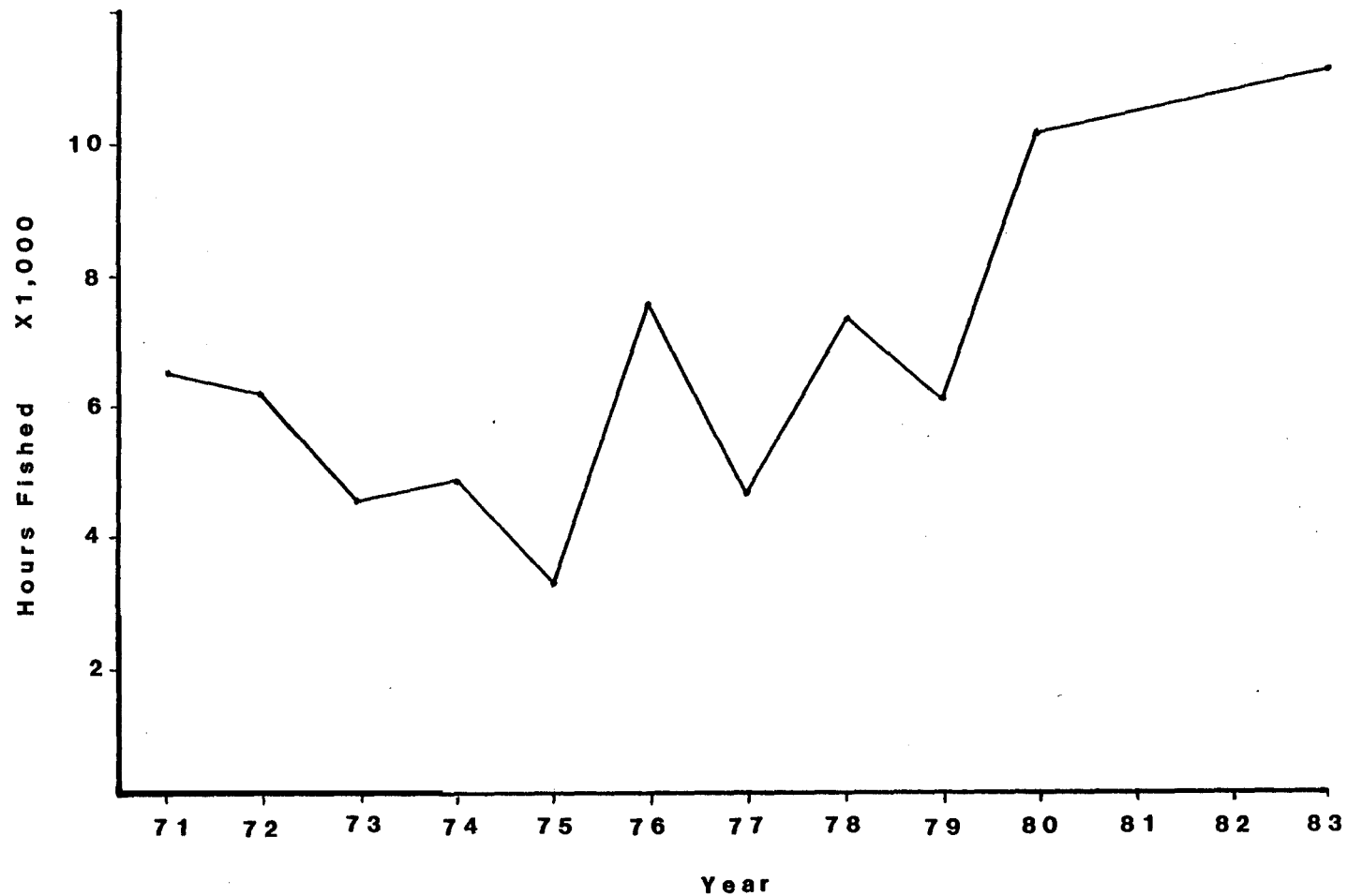


Figure 12. Estimated angler effort (hours fished) for trophy rainbow trout October 16-November 30, 1975-1983 at Garfield and Ellisport bays, Pend Oreille Lake, Idaho.

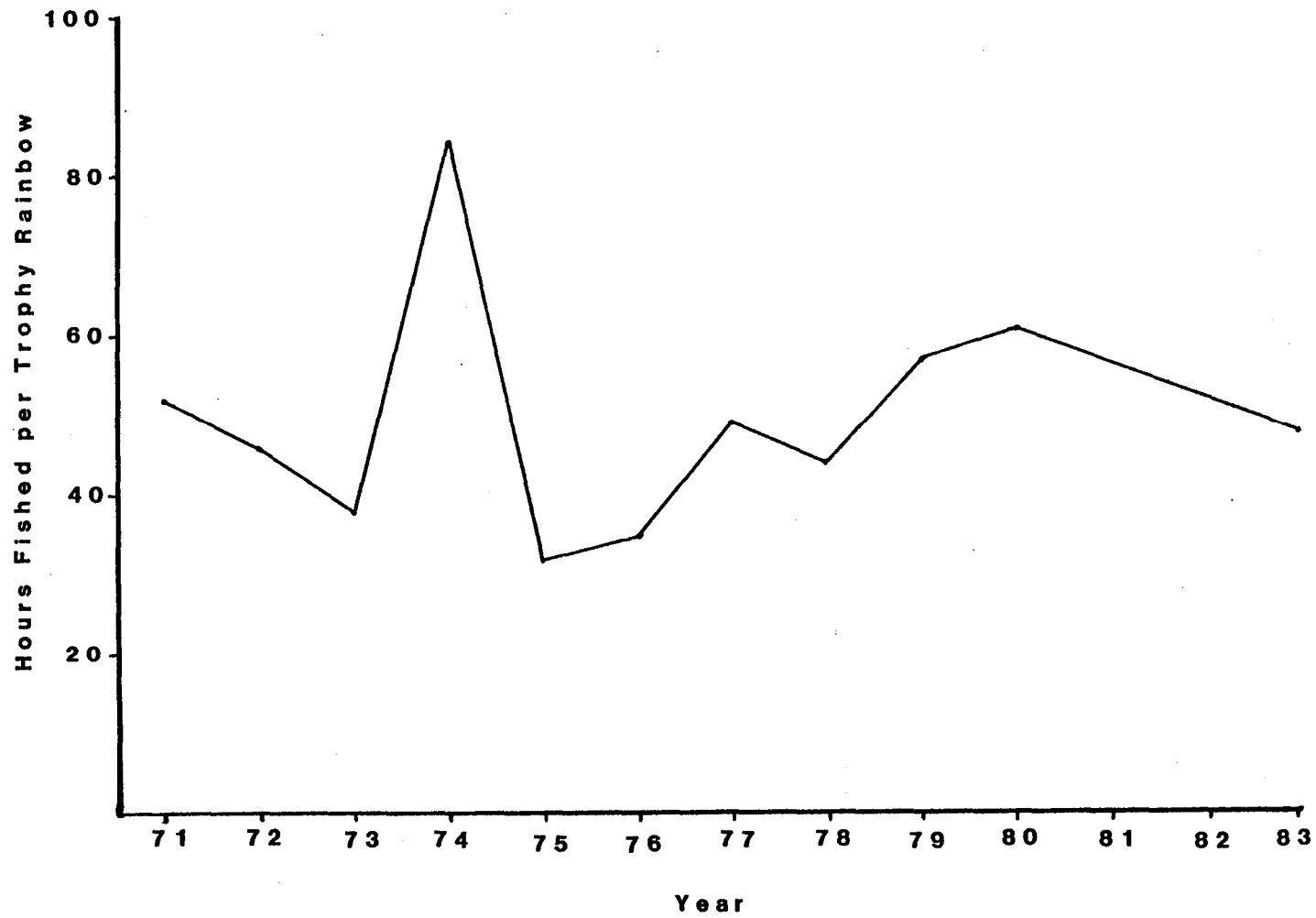


Figure 13. Average number of hours fished per trophy rainbow trout October 16 to November 30, 1975-1983 at Garfield and Ellisport bays, Pend Oreille Lake, Idaho.

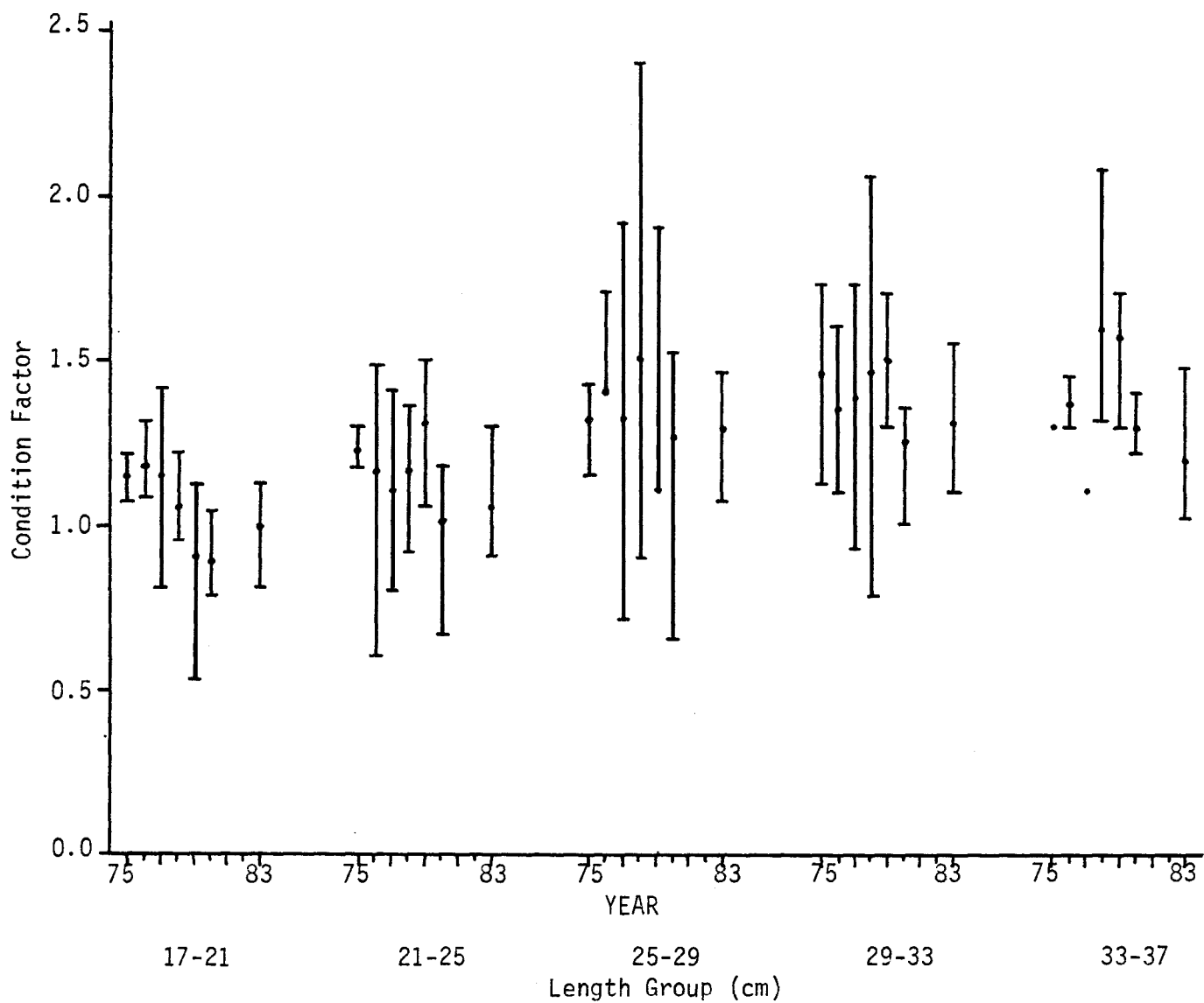


Figure 14. Average and range of condition factors for each 11 cm (4 in) length interval of trophy rainbow trout (> 43 cm) measured during creel census 1975-1980 and 1983, Pend Oreille Lake, Idaho; (a) arranged by year (top), (b) arranged by length group (bottom).

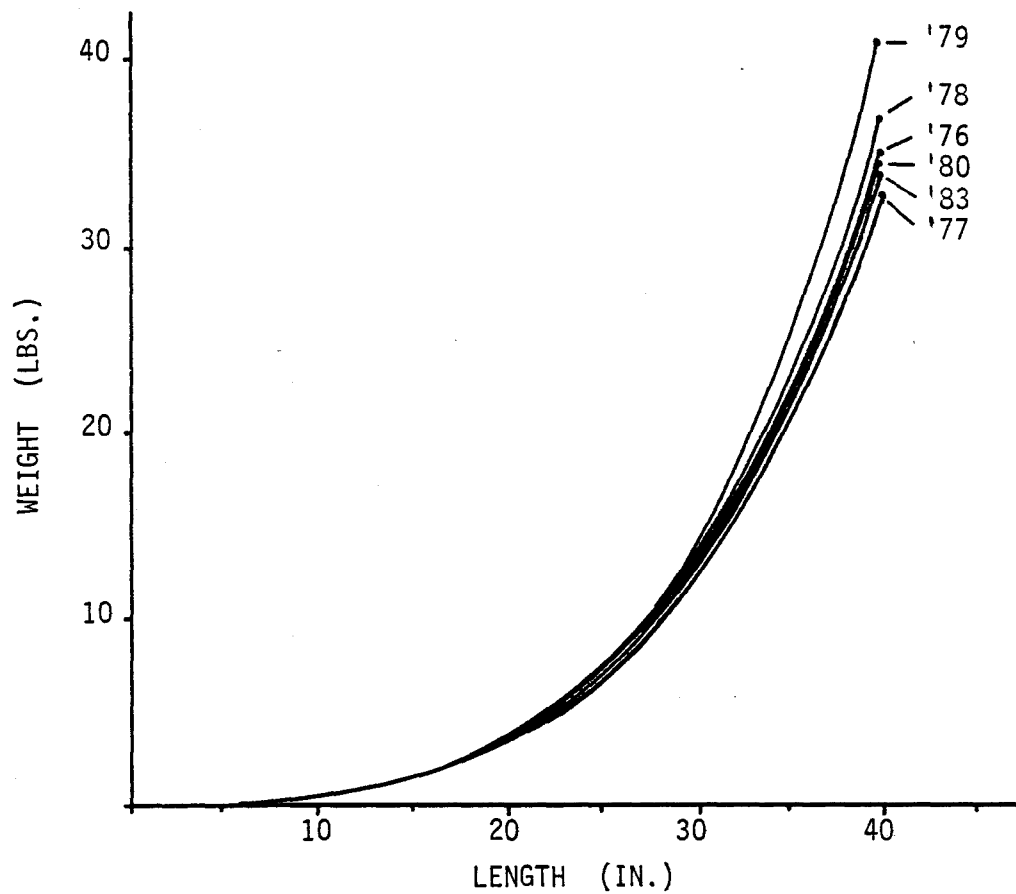


Figure 15. Predicted length-weight for trophy rainbow trout collected during creel census during 1976-1980 and 1983 from Pend Oreille Lake, Idaho.

Rainbow trout condition and projected weight were also examined within five length classes (Fig. 14, Appendix C). Some decline in condition for the smallest length group may be indicated. Variability was too great to determine any trends. Projected length-weight relationships for rainbow in the catch were also variable, but generally similar among years (Fig. 15, Appendix D).

Fish Population Structure

Age and Growth

Rainbow Trout

Anglers collected 436 rainbow trout scales. Many of these scales had eroded edges and regenerate centers and were unsuitable for age-growth analysis. Age determination and growth measurements were made on scales of 286 rainbow trout.

Rainbow trout collected in Pend Oreille Lake were between 1 and 8 years old. During their first year, rainbow trout grew 8cm (3 inches) (Table 12). Estimated lengths for other age classes was dependent upon the age juvenile rainbow migrated into Pend Oreille Lake.

The first year in the lake, rainbow trout grew 17-20 cm (7 inches). Fish that had moved into the lake as one year olds were 27.9 cm (11 inches) by the end of their second winter (Table 13). Individuals that remained in streams until their second or third year were only 13 cm (5 inches) by the end of their second winter. Most of the rainbow trout sampled had moved into Pend Oreille Lake as two-year old fish.

After at least one year in the lake, three-year old fish were 32-40 cm (13-16 inches) and four year olds were 35-50 cm (14-20 inches). Rainbow continued to grow rapidly after their first year in the lake averaging 11.5 cm (4.5 inches) per year.

Rainbow trout age and growth analysis was similar for 1983, subsample of 1972-76 data, and results of 1972-76 analysis by Anderson (1978) (Tables 14-15).

Spawning checks were evident on very few rainbow trout scales. Some rainbow trout spawned at 4 and 5 years of age. Most of the spawning occurred when fish were 6 years of age or older. Only **six** of the 286 rainbow trout aged had spawned more than once.

Bull Trout

Anglers and department personnel collected 127 bull trout scales in 1983. Age determinations and growth measurements were taken on

Table 12. Average back calculated length at age (annulus formation) for rainbow trout from Pend Oreille Lake, Idaho, 1983.

Group	Age						
	1	2	3	4	5	6	7
All fish							
cm	7.8	16.1	29.0	44.6	56.2	66.2	61.8
in	3.1	6.3	11.4	17.6	22.1	26.0	24.3
(N)	(286)	(271)	(226)	(175)	(109)	(33)	(12)
Migration at age 1	--						
cm	--	27.9	40.4	50.2	61.1	68.8	--
in	--	11.0	15.9	19.8	24.1	27.1	--
(N)	--	(53)	(43)	(28)	(16)	(3)	--
Migration at age 2	--						
cm	--	13.4	32.5	44.1	55.9	66.5	61.8
in	--	5.3	12.8	17.4	22.0	26.2	24.3
(N)	--	(202)	(167)	(137)	(87)	(28)	(12)
Migration at age 3	--						
cm	--	12.7	18.4	35.4	46.4	59.0	--
in	--	5.0	7.2	13.9	18.3	23.2	--
(N)	--	(16)	(16)	(10)	(6)	(2)	--

Table 13. Rainbow trout increments of growth (cm) for each age class and each age class for fish migrating at age 1, 2 and 3, Pend Oreille Lake, Idaho, 1983.

Group	Age groups					
	0-1	1-2	2-3	3-4	4-5	5-6
Average	7.8 (286)	8.3 (271)	12.8 (226)	15.6 (175)	11.6 (109)	10.1 (33)
Migration at age 1		<u>20.1</u> (53)	12.5 (43)	10.2 (28)	10.9 (16)	7.7 (3)
Migration at age 2		5.6 (202)	<u>19.1</u> (167)	11.6 (137)	11.8 (87)	10.6 (28)
Migration at age 3		4.9 (16)	5.7 (16)	<u>17.0</u> (10)	11.0 (6)	12.6 (2)

Table 14. Comparisons of average back calculated length at annulus in cm for rainbow trout (N) from Pend Oreille Lake, Idaho, for samples collected in 1983, a subsample of the 1972-1976 data and Anderson (1978) work from 1972-1976.

Sample	Age class					
	1	2	3	4	5	6
1983 Collection	7.8 (286)	16.1 (271)	29.0 (226)	44.6 (175)	56.2 (109)	66.2 (33)
1972-1976 Sub-sample	8.0 (61)	16.2 (53)	31.8 (39)	44.0 (26)	58.5 (16)	63.1 (4)
1972-1976 Anderson work (1978)	8.0 (378)	14.3 (375)	28.9 (329)	43.4 (258)	62.5 (163)	77.9 (40)

Table 15. Comparison of incremental growth of rainbow trout from Pend Oreille Lake, Idaho, estimated from scale samples collected in 1983, a 1972-1976 sub-sample and Anderson's 1972-1976 work (1978).

Sample	Growth between age classes				
	1-2	2-3	3-4	4-5	5-6
1983 Collection	83	12.8	15.6	11.6	10.1
1972-1976 Sub-sample	82	15.6	12.2	14.5	4.6 ¹
1972-1976 Anderson's work (1978)	63	14.6	14.5	19.1	15.4

¹A very small sample size of age 6 fish (N=4).

scales from 111 bull trout. All other scales had severely eroded edges or regenerate centers.

A bodyscale relationship was developed for bull trout using a log-log equation. Length at scale formation was estimated to be 2.2 cm

Bull trout sampled were three to **six** years old. Average back calculated lengths at annulus formation indicated bull trout grew 7.5 cm (3 inches) their first year and 11 cm (4 inches) their second, third and fourth years (Table 16). Growth rates declined when fish began to spawn at ages 6 and 7.

Cutthroat Trout

Anglers collected scales from 55 cutthroat trout. Age determinations and growth measurements were taken from scales of 54 cutthroat trout.

Cutthroat trout sampled were between one and five years of age. They grew approximately 8 cm (3 inches) per year (Table 17). Cutthroat migrated into Pend Oreille Lake as age one and two-year old fish. Due to the small sample size, growth was not calculated for each migration class.

Brown Trout

Scales were collected from seven brown trout. Brown trout sampled ranged in size from 13.6 cm (5.4 inches) to 68.6 cm (27.0 inches) and one to **six** years of age. The smallest fish was collected in a tributary stream. The other six brown trout were collected from both the Clark Fork River and Pend Oreille Lake.

All the scale samples from brown trout had an unusually large focus, without the appearance of a regenerate scale.

Composition

Rainbow Trout

Anglers recorded the lengths of 179 individual rainbow trout during the collection of length frequency data (Fig. 16). Length frequencies were derived for summer (July 15-September 15) and fall (September 16-November 30). Rainbow trout over 51 cm (20 inches) predominated the summer fishery. In the fall, 25-41 cm (13-16 inch) fish had entered the fishery. These smaller fish were two-year olds which had spent their first summer in the lake.

Length frequency and age data were used to determine an age frequency (Fig. 17). Rainbow appeared to be fully recruited to the catch at

Table 16. Average back calculated length at annulus formation and incremental growth of bull trout from Pend Oreille Lake, Idaho, 1983.

		<u>Age class</u>					
Estimated length		1	2	3	4	5	6
Length at annulus	cm	9.1	16.6	27.6	39.3	49.8	55.8
	in	3.6	6.5	10.9	15.5	19.6	22.0
	(N)	(111)	(111)	(111)	(93)	(52)	(8)
Incremental growth							
	cm		7.5	11.0	11.7	10.5	6.0
	in		3.0	4.3	4.6	4.1	2.4

Table 17. Average back calculated lengths at annulus formation and incremental growth of cutthroat trout from Pend Oreille Lake, Idaho, 1983.

Estimated length	Age				
	1	2	3	4	5
Length at annulus					
cm	8.3	14.	23.6	32.1	41.7
in	3.3	5.8	9.3	12.6	16.4
(N)	(54)	(47)	(22)	(6)	(1)
Incremental growth					
cm	6.5	8.8	8.5	9.6	
in	2.5	3.5	3.3	3.8	

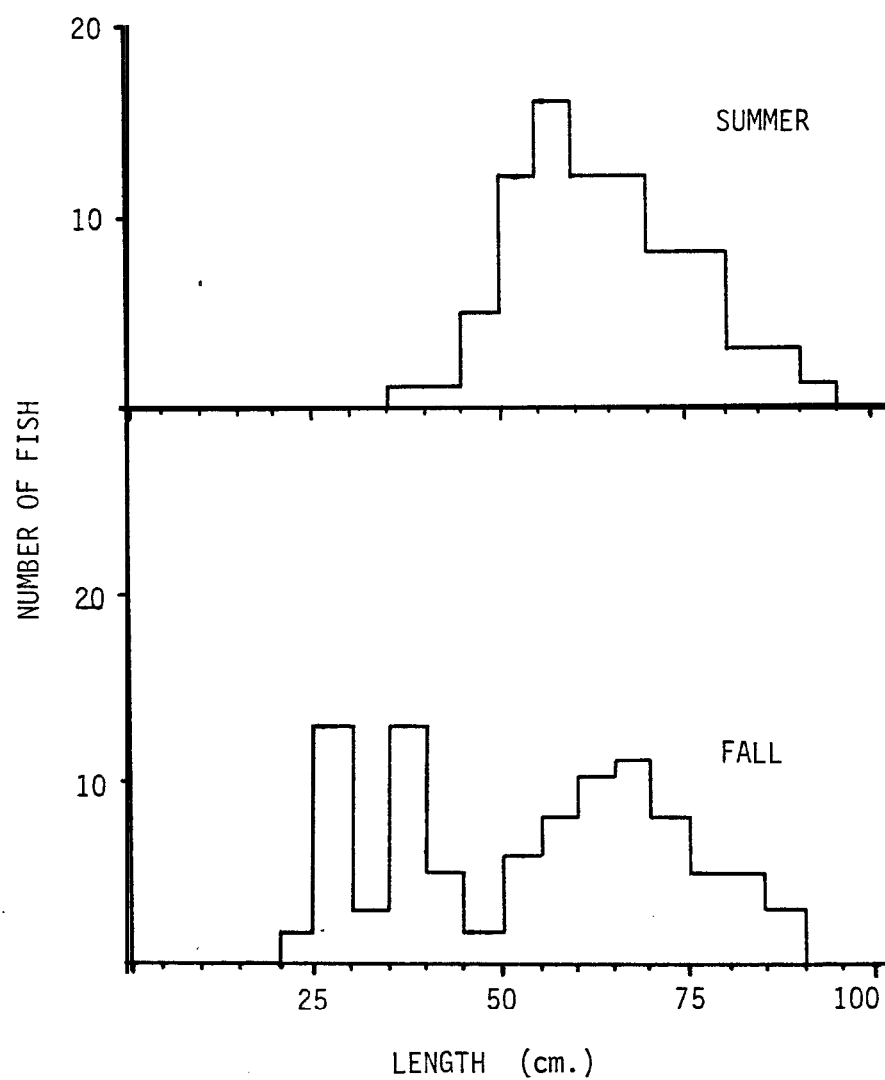


Figure 16. Length frequency of rainbow trout caught and reported by anglers in Pend Oreille Lake, Idaho, 1983.



Figure 17. Estimated age-class composition of rainbow trout caught in Pend Oreille Lake, Idaho, 1983.

age 3 or 4. A catch curve was constructed from the age frequency. Total annual mortality was estimated to be between 31 and 48 percent (Fig. 18).

Other Trout and Char

There were not enough cutthroat, bull trout or brown trout recorded in either the summer or fall period to permit the construction of length frequency, age composition, catch curve or mortality estimates.

DISCUSSION

Rainbow Trout

Spawning Areas

Rainbow trout spawning areas should be investigated further. The areas identified were very general and did not include many sites mentioned in earlier work. Idaho Fish and Game records from the 1950s report large rainbow trout use on Spring Creek, the Clark Fork River, Rapid Lightning Creek and Grouse Creek (Jeppson 1955, 1960). The largest run of spawning adfluvial rainbow was in Spring Creek with 30-60 fish reported each year from 1953-58 (Jeppson 1960).

Hartman (1969) reviews the physical characteristics of spawning sites used by stocks of large rainbow trout including the Gerrard stock. Spawning typically occurs in streams between 2.5 and 90.0 meters wide, in areas where water is 0.3-2.0 meters deep, the substrate is 23-30 cm in diameter and water velocities are between 50-90 cm/sec. Hartman (1969) states stable water velocities and little bedload movement during the incubation period were characteristic of areas used by Gerrard rainbow trout in the Lardeau River.

Rearing Areas

Juvenile rainbow trout use of middle and lower reaches of many tributaries in the Pend Oreille basin was similar to distributions of steelhead rainbow trout stocks within the Salmon drainage (Platts 1979, Thurow 1983). Cartwright (1961) reports the highest densities of Gerrard strain rainbow fry in the upper reaches of the Lardeau River. Considering the size of the Lardeau River and its position between two lakes, the area can be considered similar to the larger, lower reaches used in the Pend Oreille by juvenile rainbow.

Appropriate habitat for young-of-the-year rainbow trout may be sparse and localized in the Pend Oreille drainage. Fry used shallow, low velocity areas along the edges of the stream, typical of trout fry. Fry also used the mid-stream areas if large substrate provided small

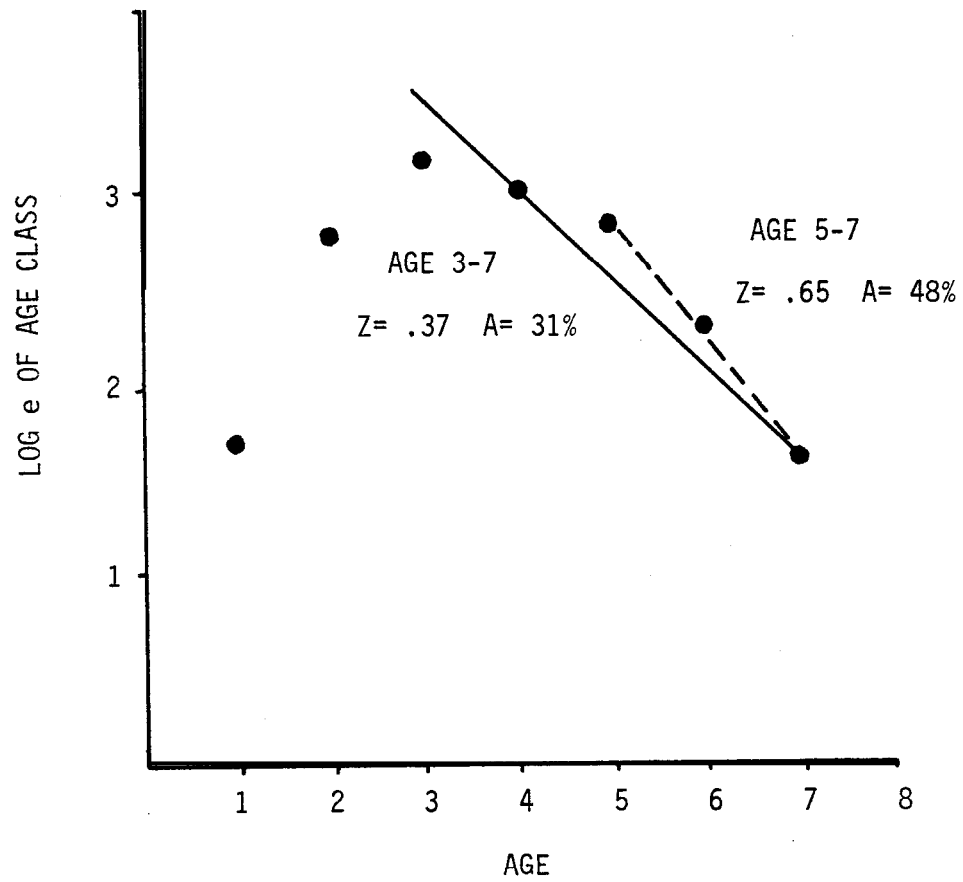


Figure 18. Catch curves for rainbow trout in Pend Oreille Lake, Idaho, 1983. Mortality is estimated using both age 3 and age 5 as the point of recruitment.

pockets of slow water and visual isolation (situations typically used by territorial trout). Rainbow fry were also seen stranded in pockets of standing water in the seasonally dry regions in the Lightning drainage. Whether rainbow use these low gradient, aggrading, wide areas to spawn in the spring and fry emerge there, or fry have dispersed into these areas is unknown. In either case, stranding may be a major cause of mortality and these areas should be considered separately in future population modeling.

Population Structure and Growth

The age at which juvenile rainbow emigrate to Lake Pend Oreille was assessed by examining growth patterns of Lake Pend Oreille rainbow in conjunction with juvenile rainbow distribution in streams. These data were confusing. Juvenile rainbow trout larger than 8 cm (3 inches) were not observed at high densities. If most of the rainbow enter the lake as two-year olds, we might expect to see more rainbow 8-13 cm (3-5 inches) in the stream. There are several possible explanations: (1) Age one juvenile rainbow were more dispersed throughout the drainage than fry and therefore, appeared less abundant than they actually were. (2) Overwinter mortality may be quite high reducing juvenile rainbow numbers. (3) Migration class may have been incorrectly assessed from the scales. Anderson (1978) also reports most rainbow in the Pend Oreille system remain in streams for 2 years. Cartwright (1961) suggest Gerrard rainbow move into Kootenay Lake as fry. Irvine (1978) studied the same Lardeau River population and reports that a large portion of juvenile rainbow migrate as fry and others remain in the Lardeau River until they are two years of age. The difference in the survival and, therefore, contribution to the population of fry migrating as one and two-year olds is not clear. Methods used to delineate migration class in this study should be refined and the contribution of each migration class to the Pend Oreille Lake population should be estimated.

Rainbow trout size is important to the trophy fishermen. Size was examined in terms of growth, length and fish weight per unit length or condition. Rainbow trout in the Pend Oreille drainage and the Gerrard strain from the Lardeau River of the Kootenay Lake drainage grew at similar rates (Cartwright 1961) (Appendix E). The condition of rainbow in the Pend Oreille drainage could be considered similar over the past 8 years, although a trend toward declining condition was noted. This trend was probably due to the declining condition of the smaller (43-58 cm, 17-21 inches) trophy fish between 1977 and 1980.

The age composition of the population and estimated mortality rates seemed to indicate fishing pressure was not limiting the rainbow trout population. However, there is other evidence that a change in the population structure may have occurred. Anderson (1978) reported repeat spawning was common and fish up to 9 years of age were present in the population. Very few fish in the 1983 collection had spawned more than once, and only one individual reached 8 years of age. The only obvious difference in Anderson's (1978) and the 1983 data was a sample of rainbow trout from the Clark Fork River included in Anderson's (1978) study.

Annual mortality may have been underestimated due to sampling procedures. It became evident, particularly in the summer sample, that anglers released small fish before measuring them in the hopes of reducing stress and increasing fish survival. The number of small rainbow entering the cutthroat trout fishery was also under-represented because there were not many cutthroat fishermen participating in the collection of representative length frequency data.

Bull Trout

Spawning Areas

Bull trout spawn in a small portion of the accessible tributaries of the Pend Oreille drainage. Relatively small, key bull trout spawning areas have been identified and monitored in other drainages including North and Middle Fork of the Flathead and the Swan Lake drainages (Shepard and Graham 1983, S. Leathe, Montana Department of Fish, Wildlife and Parks, personal communications). The key areas in the Pend Oreille system could be monitored from year to year with very little effort to assess the status of bull trout populations in the lake.

Bull trout spawning escapement was estimated to be 3,175 fish in 1983. The number of spawning bull trout per unit area of Pend Oreille Lake was comparable to similar measures for Flathead Lake but an order of magnitude less than Swan Lake (Table 18). In the Swan Lake system, there was some evidence that estimates of 2 fish per redd may be more appropriate for that drainage than the 3.9 fish per redd derived for the Flathead River basin. To ensure the most accurate escapement estimate, the number of adult bull trout per redd could be determined for the Pend Oreille drainage. From observations in 1983, it seems likely that a higher number of fish per redd could be expected in Trestle Creek than other Pend Oreille tributaries. Trestle Creek is unique because it seemed to have a large number of small, presumably male bull trout participating in spawning activities.

Future spawning counts should explore a few additional areas including the Clark Fork River, the upper end of Porcupine Creek, upper Grouse Creek and the upper reaches of Savage Creek. Jeppson (1960) reported 114 adult bull trout in the Clark Fork River below Cabinet Gorge dam on October 16, 1960. The US Forest Service has reported bull trout in Caribou, McCormick, Spring, Trout, South Fork Grouse and Plank creeks. Idaho Fish and Game records from the 1950s report limited bull trout spawning in Rapid Lightning Creek and Berry Creek, as well as an adult fish seen in lower Trout Creek (Jeppson 1955). Although Spring and Rapid Lightning creeks were well surveyed for bull trout redds in 1983, none were observed. All these areas should be examined for a complete current record.

Table 18. Comparison of adfluvial bull trout population densities in Pend Oreille Lake, Idaho; Flathead Lake, Montana; and Swan Lake, Montana.

Drainage	Surface area of lake (km ²)	Number of redds	Year	Fish/ ¹ redd	Estimated escapement	Adult density
Pend Oreille	383	814	1983	3.9	3,175	8.2/km ²
Flathead	477	1,300	1982	3.9	5,070	10.6/km ²
Swan	10.1	220	1982	3.9	858	84.9/km ²
		260	1983	3.9	1,014	100.4/km ²

¹Estimate from Fraye et al 1981.

²Number of redds expanded from actual counts of monitoring area.

Granite Creek probably provides more bull trout spawning areas than the 1983 records indicate. In 1954 and 1956, 29 and 30 bull trout redds were located in Granite Creek and 8 in Sullivan Springs (Jeppson 1955, Whitt 1957). The 1983 redd counts were conducted late in October and redds were already obscured by sediment and difficult to count. Bull trout movement into Granite Creek was probably impaired by the maze of beaver dams in the lower end of the drainage.

The timing of redd counts will affect the numbers of redds seen. Bull trout seemed to spawn in different drainages earlier than others. For instance, the earliest spawning was observed in Trestle Creek; therefore, this stream should be the first one counted. Redd counts should begin in Trestle Creek the last week of September. All redd counts should be completed by the third week in October. Algae and silt may obscure redds if counts are conducted too late in the year.

Twin and Johnson creeks may also have many more redds than the 1983 record if counts are conducted later. However, the unique problem in these streams will be distinguishing between bull trout and brown trout redds. Brown trout typically spawn later in the year than bull trout so two separate counts, a late September and late October or early November count, should provide information on both species.

Many adult bull trout in the Pend Oreille system appear to enter tributary streams early in the year when flows are still high. This was particularly obvious in the Lightning drainage. Most of the spawning in tributaries to Lightning Creek were upstream from both the seasonally dry area in Lightning Creek and seasonally dry areas in the tributaries. This is uncommon. In the Flathead, bull trout do not usually move above seasonally dry areas. There is one location in both the Middle Fork of the Flathead and Swan drainages where a few bull trout were found above a seasonally dry stream channel (S. Leathe, Montana Department of Fish, Wildlife and Parks, personal communications).. In the Pend Oreille, 37% of the spawning bull trout were above seasonally dry sections of stream.

Rearing Areas

Juvenile bull trout were found in the upper and middle reaches of accessible streams. They were often associated with cutthroat trout, but were not observed in low gradient, downstream reaches where rainbow and brook trout were prevalent. Bull trout were found in the upper reaches of the St. Joe and Salmon River drainages (Mauser, unpublished data; Thurow 1983). In contrast, the distribution of bull trout was not limited to the upper reaches of streams in the Flathead basin; in fact, in some areas juvenile bull trout densities were relatively high in the lower reaches (Fraley et al. 1981, Shepard et al. in press). Bull trout were associated with cutthroat trout in other drainages including the St. Joe, Salmon and Flathead.

At the sites where bull trout were present in the Pend Oreille, their densities were within the range of values seen in the Flathead and Priest Lake systems (Mauser and Horner 1982, Shepard et al. 1982).

Comparisons of bull trout rearing habitat quality and quantity in the Pend Oreille to other regions is difficult due to the lack of basic habitat inventory data in the Pend Oreille. A model which can effectively predict bull trout densities on the basis of habitat parameters should also be developed. Guidelines for quantifying habitat (which would be comparable to other drainages with bull trout) can be found in Montana Department of Fish, Wildlife and Parks (1983). Habitat criteria which would be helpful in the development of a model to predict bull trout use of an area can be found in Pratt (1984), work by Leathe to be published in 1984 or 1985, and the Flathead River basin studies (Graham et al. 1980, Fralaye et al. 1982, Shepard et al. 1982, Shepard et al. 1984).

Population Structure and Growth

Estimated growth rates for bull trout in the Pend Oreille drainage were slightly higher than those reported for other drainages (Table 19).

Spawning checks were noted on scales of bull trout aged as 6 and 7 year old fish. Bull trout in the Flathead basin mature at age 6 (Leathe and Graham 1982).

During this study, and in past Idaho Department of Fish and Game reports, "small" bull trout were observed in the spawning beds. Jeppson (1953) calls these fish Jacks or precocial males. Small mature male bull trout were not commonly observed in the Flathead River basin (Shepard et al. 1983).

Age composition and mortality estimates for bull trout were not possible this year due to small sample sizes, but should be attempted in the future.

Cutthroat Trout

Spawning and Rearing Areas

Adfluvial cutthroat trout spawning and rearing areas are poorly defined in the Pend Oreille system today. In the past, Idaho Fish and Game reports indicate that cutthroat were prevalent and spawned throughout the drainage:

"Cutthroat spawning areas are more widespread than those of other salmonids. Spawning runs have been known to occur in almost all tributary streams with access from the lake and suitable spawning gravel. The cutthroat is the most common species of trout in Pend Oreille Lake." (Jeppson 1955).

Cutthroat were widespread in the drainage in 1983. However, in areas which could be used by adfluvial cutthroat trout densities were low in the Pend Oreille system in comparison with other adfluvial spawn-

Table 19. Bull trout growth (millimeters) in various waters (adapted from Leathe and Graham (1982).

		Total length (cm) at annulus								
		I	II	III	IV	V	VI	VII	VIII	IX
Pend Oreille Lake 1983	mm (n)	9.1 (111)	16.6 (111)	27.6 (111)	39.3 (93)	49.8 (52)	55.8 (8)	--	--	--
Flathead Lake Leathe and Graham (1982)	mm (n)	6.8 (929)	13.0 (929)	20.4 (926)	29.2 (851)	38.4 (601)	47.2 (290)	56.7 (102)	65.8 (28)	73.1 (4)
Block (1955)	mm (n)	7.6 (80)	15.0 (51)	23.4 (44)	33.5 (43)	45.7 (41)	56.6 (31)	69.1 (15)	78.0 (1)	-- --
Rahrer (1963)	mm (n)	7.1 (289)	14.0 (289)	20.8 (289)	32.3 (245)	45.2 (203)	59.4 (80)	72.4 (14)	87.6 (1)	-- --
North and Middle Fork Flathead tributaries Fraley et al (1981)	mm (n)	7.2 196)	10.8 (97)	14.0 (16)						
Middle Fork Flathead River Fraley et al (1981)	mm (n)	4.8 (122)	9.7 (83)	17.4 (41)	28.6 (31)	38.9 (31)	48.4 (29)	57.5 (14)	63.6 (3)	-- --
Hungry Horse Reservoir 1953 & 1972 Huston (1974)	mm (n)	7.2 (212)	14.4 (212)	22.5 (185)	32.4 (130)	42.9 (60)	51.3 (28)	59.4 (5)	67.1 (3)	-- --
Lake Koocanusa May et al (1979)	mm (n)	6.7 (162)	12.3 (162)	21.2 (157)	30.9 (96)	39.0 (37)	48.2 (11)	51.8 (1)	-- --	-- --
Priest Lake Bjornn (1961)	mm (n)	7.1 (61)	11.4	18.3	31.0	42.4	51.6	60.5	--	--
Upper Priest Lake Bjornn (1961)	mm (n)	6.6 (41)	10.2	15.5	23.9	35.8	46.2	54.6	61.2	--

ing and rearing areas (Lukens 1978, Fralry et al. 1981, Shepard et al. 1984).

The low densities of juvenile cutthroat in accessible streams in 1983 and the declining cutthroat trout harvest in the Pend Oreille drainage points toward a declining cutthroat trout population. Cutthroat trout populations have declined in other areas due to habitat loss, angler harvest and hybridization (Rankel 1971, Behnke 1971). Hybridization between cutthroat and rainbow trout does occur in the Pend Oreille drainage. Many anglers refer to these fish as "cutbows." The extent of hybridization is unknown. The loss of adfluvial cutthroat trout spawning and rearing habitat in accessible tributaries cannot be quantified without further investigation. Local sportsmen in the Clark Fork and Sandpoint areas concerned about angler harvest on cutthroat trout populations, supported restrictive regulations in the Lightning Creek drainage (Idaho Department of Fish and Game files).

Population Structure and Growth

Westslope cutthroat trout growth rates seem to be rapid in the Pend Oreille (Table 20). Growth rates of Pend Oreille fish were calculated with the assumption that all fish formed scales their first year. In many westslope cutthroat trout populations, this is not the case. Data was not available to substantiate whether or not cutthroat in the Pend Oreille drainage form an annulus the first year.

Age composition and mortality estimates for cutthroat trout were not possible this year due to a small sample size.

Other Trout and Char

Brook trout were prevalent in several tributaries to Pend Oreille. Most brook trout populations were probably resident fish. A few scales were collected from brook trout by anglers from the lake. This raises the question whether adfluvial brook trout exist in the system.

Brown trout in the Pend Oreille are probably fluvial and adfluvial. This species seemed to be concentrated in the Clark Fork River area.

Lake trout have been caught infrequently in Pend Oreille Lake. No data was collected this year concerning this species.

ACKNOWLEDGMENTS

This study was possible through the cooperative effort of sportsmen and agency personnel.

I would like to thank all the members of the Lake Pend Oreille Idaho Club, Trout Unlimited and the resort owners around the lake for their

Table 20. Calculated mean total lengths of westslope cutthroat trout from various western streams in Idaho and Montana (adapted from Lukens 1978).

Location	Number of fish	Computed mean length at each annulus (mm)					
		1	2	3	4	5	6
Pend Oreille Lake 1983	54	83	148	236	321	417	
Wolf Lodge Creek (Lukens 1978)	324	73	111	136	185	--	--
Hungry Horse Creek (Huston 1969, 1971, 1972, 1974a)	1,239	73	121	162	--	--	--
Young Creek (May and Huston 1974)	92	49	109	160	--	--	--
St. Joe River tributaries (Averett 1963)	161	72	142	216	--	--	--
St. Joe River (Rankel 1971)	347	52	91	143	192	243	291
Priest and Upper Priest Lake tributaries (Bjornn 1957)	232	85	129	171	201	254	--
North Fork Flathead River tributaries (Johnson 1963)	106	58	114	178	216	244	302
Main rivers of Flathead River drainage (Johnson 1963)	559	56	119	196	287	333	378
Salmon River (Mallet 1963)	474	60	100	174	254	322	371
Kelly Creek (Johnson 1977)	208	66	101	153	212	251	306

participation in the project. Private sportsmen including Tom Mehler, Mike Ruskey, Maxine Congelton, George Congelton, Fred Page, Barry Kendall and Gil Norler were exceptionally active during the study. Dave Thorsen (USFS) was a valuable source of information. Vern Ellis (IFG) coordinated the collection of age and growth data and conducted the creel census. John Scott (IFG) was an endless source of information and collected most of the bull trout age-growth data. Keith Hawn, Allan Williams, Bruce Thompson, Gregg Mauser, Jody Brostrom and Bruce Rieman also participated in the study. A very special thanks to Bob Anderson of Washington Water Power for his guidance interpreting rainbow trout scales.

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APPENDICES

Appendix A. Data provided by the USFS concerning the physical character of streams surveyed in Lake Pend Oreille drainage, 1983.

Stream	Total length (km)	Length accessible (km)	Drainage area (km)	Percent' gradient
Lightning	34.9	28.5	285.4	2.9%
Rattle	6.6	5.9	27.8	7.9%
Wellington	7.4	1.3	39.9	6.4%
East Fork	8.2	6.4	52.9	--
Savage	5.0	1.8	--	9.7%
Charr	2.7	0.6	--	--
Thunder	1.8	1.8	--	--
Porcupine	5.1	2.7	19.5	11.8%
Morris				
Cadcade	4.3	0.6	--	--
Spring	8.2	2.4	--	--
Trestle	13.0	10.2	51.4	--
Pack River	59.0	50.6	321.2 ²	--
McCormick	6.6	0.6	--	--
Pearson				
Jeru	4.0	0.0	--	--
Lindsey		0.0	--	--
Hell roaring	9.4	0.0	--	--
Tavern				
Caribou	9.1	6.2	--	--
Berry	11.2	0.0	--	--
Colburn				
Sand				
Grouse	29.3	27.5	94.1	--
N. Fork Grouse	8.2	7.0	38.4	--
S.Fork Grouse	6.6	1.9	--	9.1%
Gold	--	--	--	--
Rapid Lightning	17.1	2.7	83.1	4.1%
Trout	8.0	2.1	25.7	
Sandpoint Creek		--	--	--
Little Sand	9.9	--	--	--

Appendix A. Continued.

Stream	Total length (km)	length accessible (km)	Drainage area (km ²)	Percent' gradient
Schweitzer Spring Jack	--	--	--	--
Twin	11.8	4.2	37.8	--
Johnson	8.6	1.8	36.4	--
Granite	13.9	4.6	17.7	--
Falls	5.0	0	--	--
Cedar	5.6	1.8	--	--
North Gold	10.2	1.1	42.9	5.9%
South Gold	2.9	2.6	56.6	
west Gold	6.7	0	--	8.2%

¹Percent gradient of entire stream.

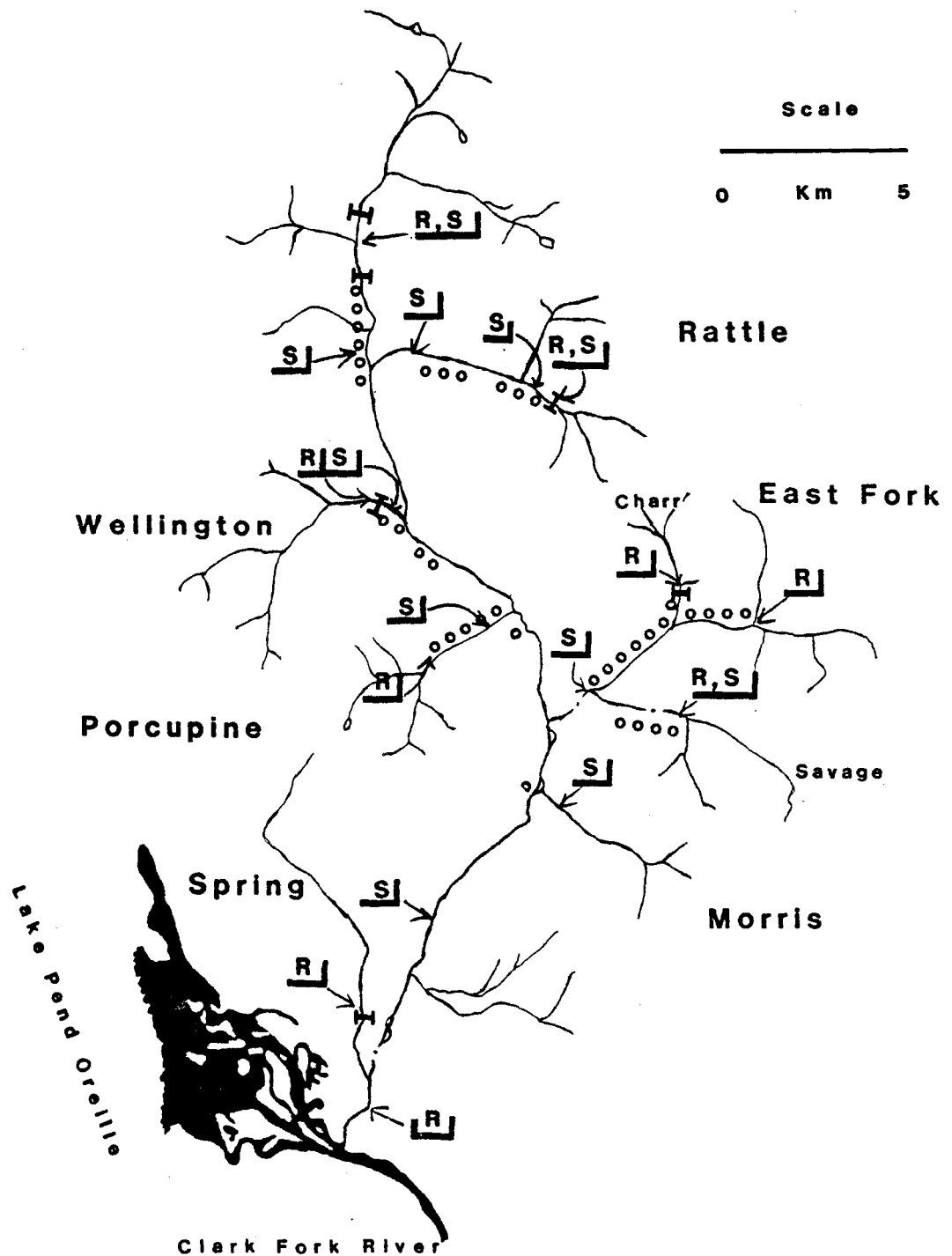
²Drainage area measured above (upstream) Highway 95 crossing.

Appendix B. Maps of tributaries to Lake Pend Oreille Idaho including the location of snorkeling surveys, redd surveys and bull trout redds observed during the 1983 field season.

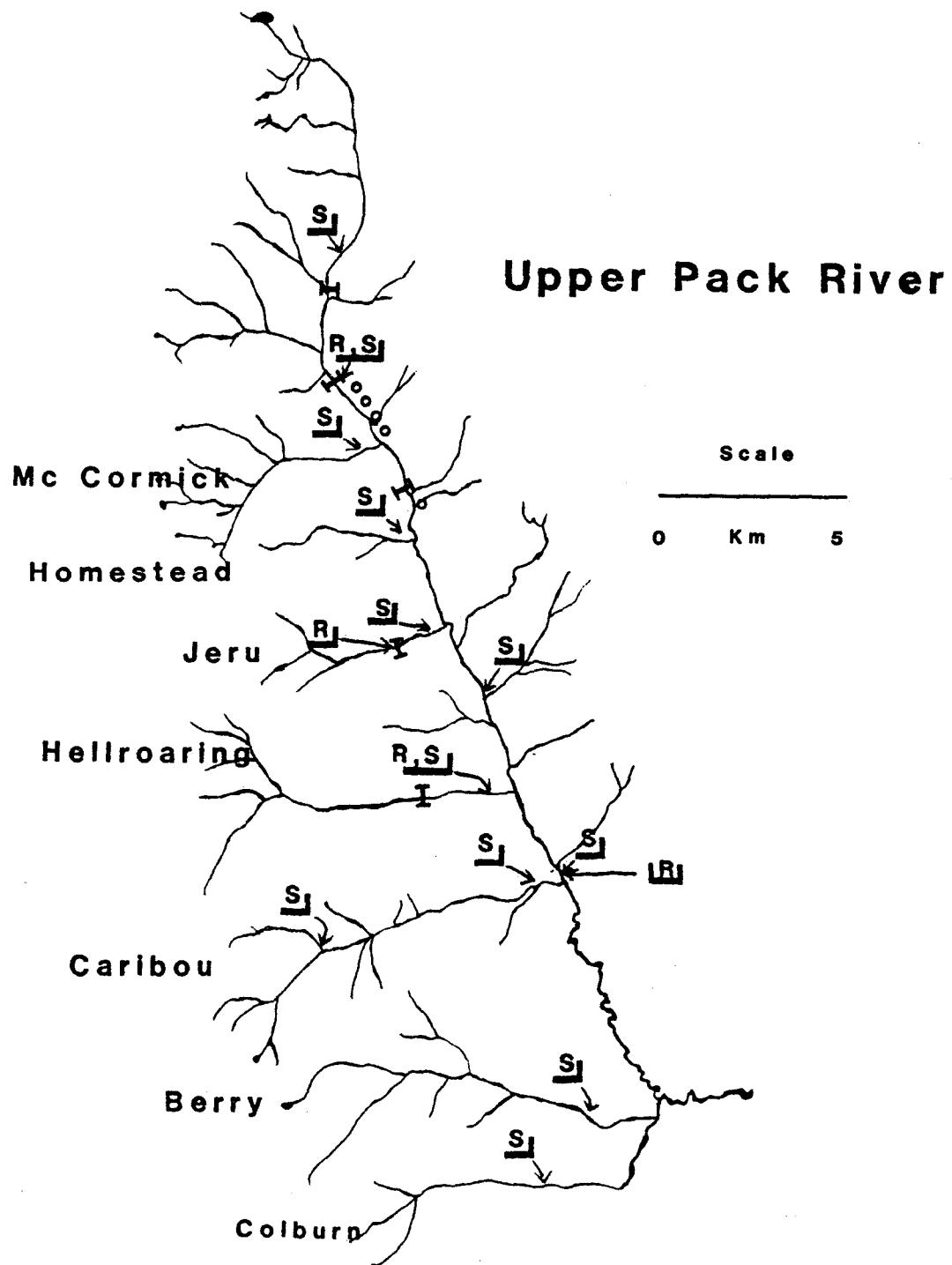
KEY TO SYMBOLS USED IN APPENDIX B

S	Snorkeling site
R	Upstream end of bull trout redd surveys 1983
R	Downstream end of bull trout redd surveys 1983
0000	Bull trout redds location
H	Water falls which were primarily barriers
...	Intermittent section of stream

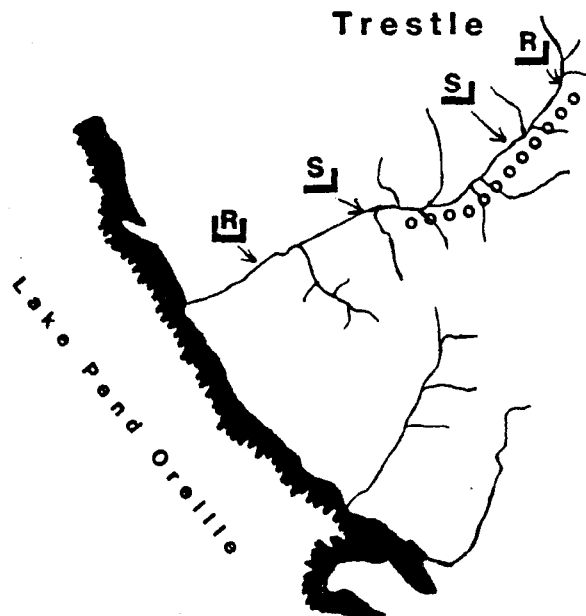
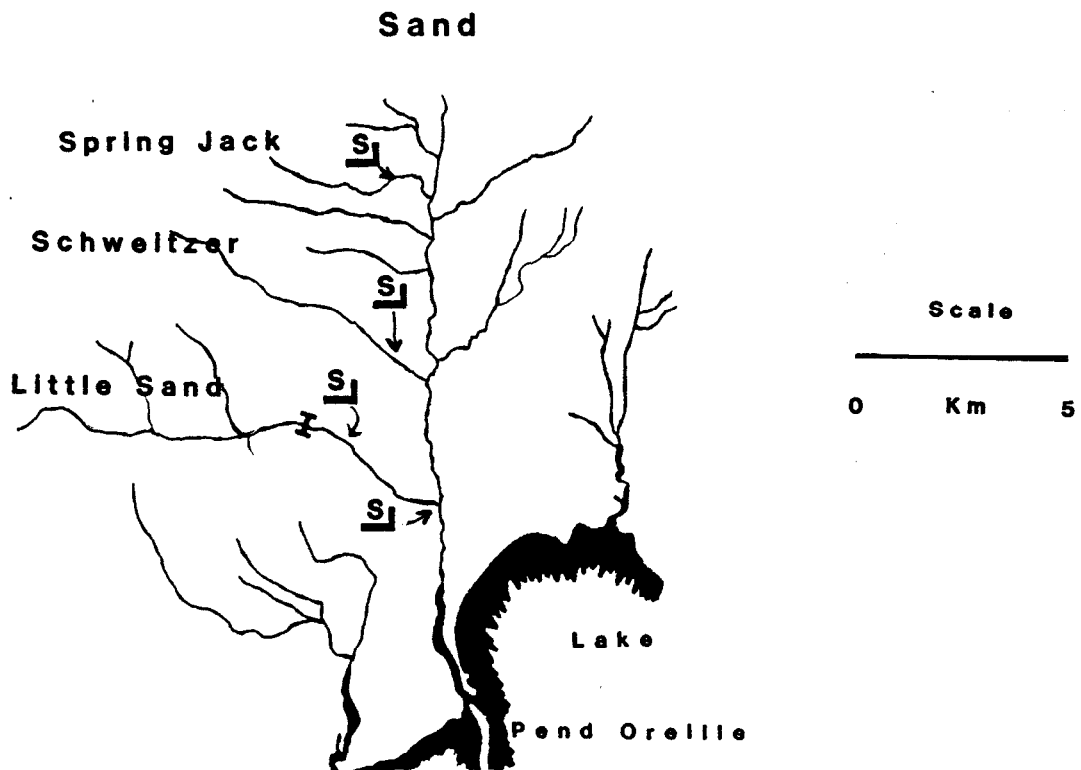
Lightning Creek



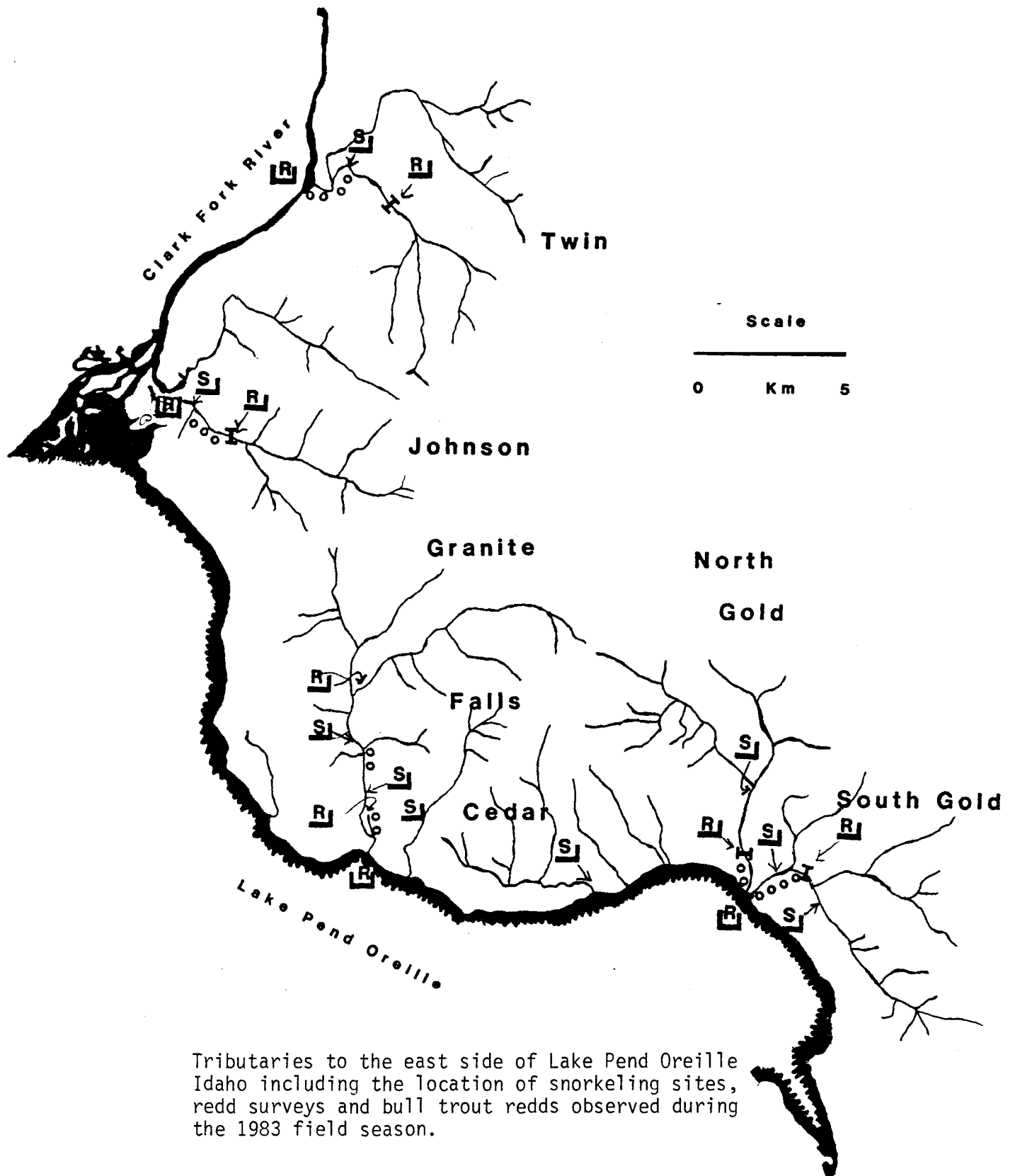
The Lightning Creek drainage including the location of tributary streams, snorkeling sites, redds surveys and bull trout redds observed during the 1983 field season.



The Pack River drainage above the junction of Highway 95 and the Colburn culvert cut off road including the location of tributary streams, snorkeling sites, redd surveys and bull trout redds observed during the 1983 field season.

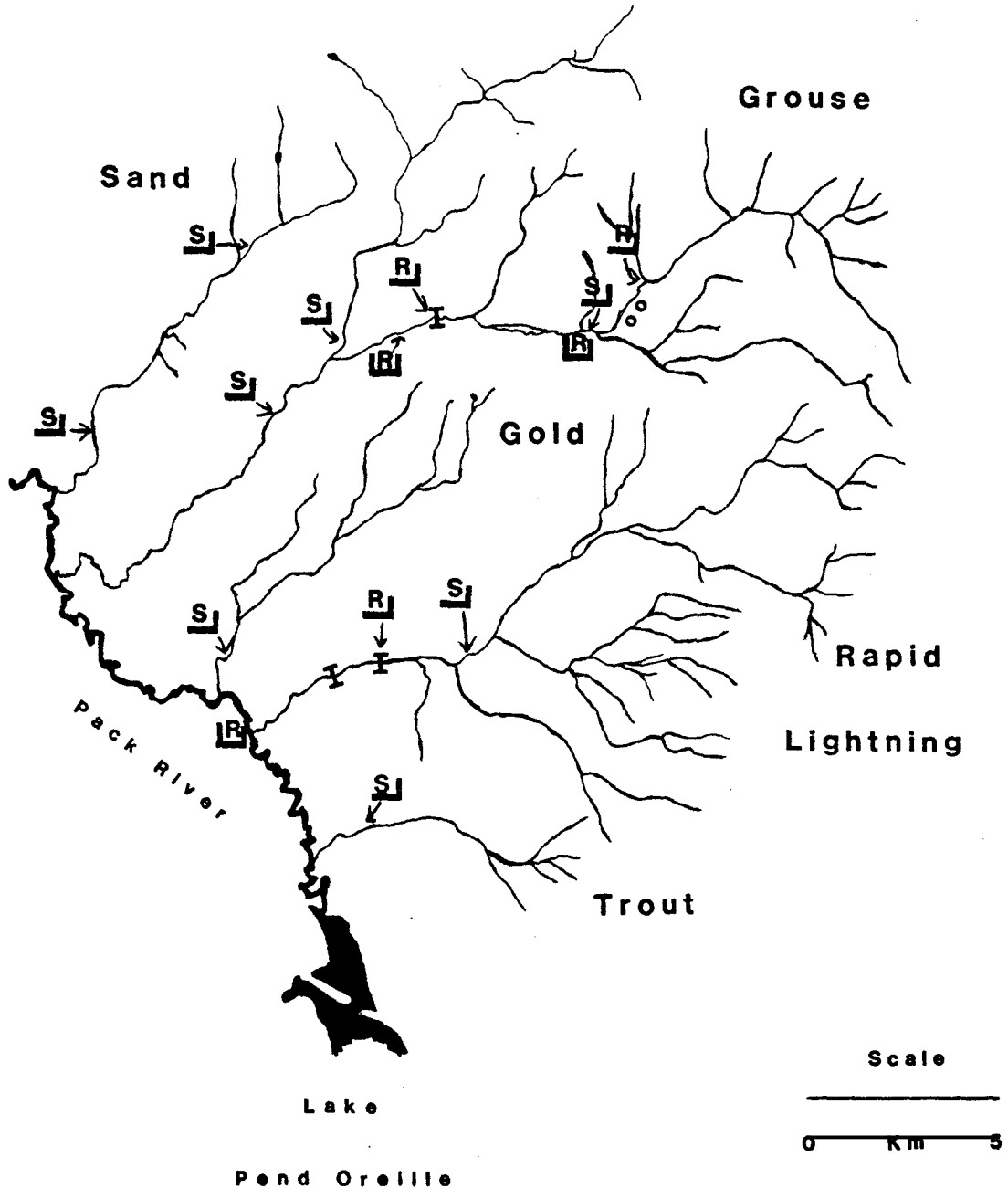


Sandpoint and Trestle creeks and the location of snorkeling sites, redd surveys and bull trout redds observed during the 1983 field season.



Tributaries to the east side of Lake Pend Oreille Idaho including the location of snorkeling sites, redd surveys and bull trout redds observed during the 1983 field season.

Lower Pack River



The Pack River drainage below the junction of Highway 95 and the Colburn culvert cut off road including the location of tributary streams, snorkeling sites, redd surveys and bull trout redds observed during the 1983 field season.

Appendix C. weights predicted for various size (length) from length-weight equations derived for trophy rainbow trout in Pend Oreille Lake, 1975-1980 and 1983.

Year	Unit weight	Length group					
		<u>43 cm</u> (17 in)	<u>51 cm</u> (20 in)	<u>63 cm</u> (25 in)	<u>76 cm</u> (30 in)	<u>89 cm</u> (35 in)	<u>102 cm</u> (90 in)
1975	kg (lbs)	0.8 (1.7)	1.4 (3.0)	2.9 (6.5)	5.6 (12.4)	9.6 (21.2)	15.4 (33.9)
1976	kg (lbs)		1.3 (2.8)	2.8 (6.2)	5.5 (12.1)	9.7 (21.3)	15.7 (34.7)
1977	kg (lbs)	0.7 (1.6)	1.4 (3.0)	3.2 (7.0)	6.3 (13.8)	11.2 (24.6)	18.4 (40.6)
1978	kg (lbs)		1.4 (3.0)	3.1 (6.8)	5.9 (13.1)	10.4 (22.9)	16.8 (37.1)
1979	kg (lbs)	0.7 (1.9)	1.5 (3.3)	3.1 (6.9)	5.8 (12.8)	9.7 (21.4)	15.2 (33.5)
1980	kg (lbs)	0.7 (1.9)	1.5 (3.3)	3.2 (7.1)	6.0 (13.2)	10.1 (22.2)	15.8 (34.9)
1983	kg (lbs)	1.0 (2.2)	1.7 (3.7)	3.5 (7.7)	6.3 (13.9)	10.3 (22.8)	16.0 (35.2)

Appendix D. Length-weight equations derived for trophy rainbow trout collected
October 16-November 30, 1975-1983, Pend Oreille Lake, Idaho.

Year	N	Equation derived	1-2
1975	36	$W=2.34 \times 10^{-4} L^{5.23}$	0.75
1976	80	$W=1.34 \times 10^{-4} L^{3.30}$	0.96
1977	51	$W=1.42 \times 10^{-4} L^{3.35}$	0.91
1978	19	$W=6.05 \times 10^{-5} L^{3.61}$	0.96
1979	24	$W=3.99 \times 10^{-5} L^{3.75}$	0.95
1980	36	$W=4.87 \times 10^{-5} L^{3.65}$	0.94
1981			
1982			
1983	56	$W=8.04 \times 10^{-5} L^{3.51}$	0.98

Appendix E Mean fork length (cm) of each year class of Kootenay Lake rainbow trout from 1942 to 1957 inclusive. Determined by back calculation, using the method of Smith (1955), from scales of angler caught trout; numbers in parentheses are inches. From "Cartwright (1961)."

Year class	Mean fork length (cm) at ages I to VII						
	I	II	III	IV	V	VI	VII
1942	7.06 (2.08)	20.8 (8.2)	30.1 (11.8)	40.9 (16.12)	53.9 (21.25)	68.3 (26.87)	78.0 (30.75)
1943	6.84 (2.7)	14.6 (5.75)	32.6 (12.8)	50.3 (19.8)	66.9 (26.37)	74.7 (29.4)	-- --
1944	5.70 (2.25)	12.2 (4.8)	27.4 (10.8)	45.7 (18.0)	58.2 (22.9)	--	-- --
1945	6.47 (2.55)	14.5 (5.7)	28.7 (11.3)	41.9 (16.5)		--	-- --
1946	5.97 (2.3)	12.1 (4.75)	25.6 (10.1)	41.9 (16.5)	59.4 (23.37)	--	-- --
1947	6.55 (2.6)	15.2 (6.0)	23.7 (9.3)	36.9 (14.55)		67.4 (26.55)	-- --
1948	6.03 (2.37)	15.1 (5.9)	29.1 (11.4)	52.8 (20.8)	--	--	-- --
1949	6.39 (2.5)	14.6 (5.75)	27.7 (10.9)	43.7 (17.2)	62.9 (24.75)	71.4 (28.12)	-- --
1950	6.46 (2.55)	15.2 (6.0)	29.2 (11.5)	41.5 (17.35)	66.5 (26.15)	79.5 (31.25)	-- --
1951	5.53 (2.17)	12.4 (4.87)	27.5 (10.8)	46.7 (18.37)	--	--	72.4 (28.5)
1952	5.77 (2.25)	12.2 (4.8)	27.7 (10.9)	44.2 (17.4)	56.0 (22.1)	68.6 (27.0)	--
1953	6.15 (2.4)	12.5 (4.9)	28.9 (11.37)	44.5 (17.5)	59.8 (23.55)	78.5 (30.8)	--
1954	6.33 (2.5)	13.5 (5.3)	29.2 (11.5)	48.0 (18.9)	61.8 (24.35)		--
1955	6.31 (2.5)	13.5 (5.3)	28.8 (11.35)	48.7 (19.2)	--	--	--
1956	7.00 (2.8)	15.5 (6.12)	32.3 (12.75)	--	--	--	--
1957	7.31 (2.87)	17.4 (6.87)	--	--	--	--	--

